

Concrete

Vol. 24

Detroit, June, 1924

No. 6

Stimulating Pride of Craft in the Construction Field

BUILDING contractors not infrequently complain that there is nothing implied in passing out a union card which distinguishes the possessor as a good, bad or indifferent workman.

They complain that the tendency of the union is to create a mean level of accomplishment—a level not merely mean but sometimes ornery. In short, there is very often lacking a workmanly pride of accomplishment, a human factor that influences very strongly not only the amount of work a man does, but the quality thereof.

Just how much effort do the building contractors make to stimulate *pride of craft*?

Just how much recognition do the contractors give to the individual workman who excels, the workman who possesses that all-important urge which distinguishes the dabbler from the skillful worker in every walk of life?

There are, in all probability, a few specially exalted souls whose bright and shining light is wholly from within and no word of praise or blame affects one iota their devotion to the day's task. They are few. We occasionally read about them. We have never seen one. They are few indeed who do not respond to personal recognition.

Hasn't the contractor, like the manufacturer, been concerned chiefly with output in the mass? He has fine sets of charts showing how the job moves along and he calls upon his superintendents to meet his schedules. Hasn't the contractor been concerned to find machinery to eliminate hand labor—to do the work of many hands? Does he remember as often as he might that behind the success or failure of every machine is a man and that in between the machines are men who form the links in the chain of operations, and that here and there, a man stands out above the rest like a torch in a cave? He stands out because he puts into his task the fine elements of himself.

Nothing perhaps would do more to improve the general building situation than the development of a *pride of craft* among the artisans and mechanics of the industry.

With some such thought, the Philadelphia Building

Congress has decided to be, henceforth, on the alert to discover craft skill, and, having discovered it, to reward it. Wages are a partial reward, but that human element which lifts a workman above the common herd is not wholly at the bidding of wages. Such a workman finds a portion of his reward in the work itself and, being human, a recognition of the work.

Whether or not the Philadelphia Building Congress is to accomplish something is only a guess at this time. At least the plan to present certificates to "craftsmen," "assistant craftsmen," "junior craftsmen," "guildsmen," "master craftsmen" and so on, has the virtue to sense that there is a quality of workmanship which is superior to the pay check.

Plans more in detail, as to the award of certificates are as follows:

Craftsmen. To those, now designated by various names such as Mechanics, Artisans, Skilled Workers, etc., who in any building craft have shown skill, ability, efficiency, willingness and the desire to improve their own knowledge and technique as well as that of fellow workers, helpers or apprentices,—a *Certificate as a Craftsman*.

Assistant Craftsman. To those, now designated as Improvers, Helpers, etc., who give indication of the proper qualifications and the desire to become craftsmen, or to those who are satisfactorily completing terms of apprenticeship, and have shown the characteristics described in the preceding paragraph,—a *Certificate as an Assistant Craftsman*.

Junior Craftsman. To those now designated as Apprentices, Learners, etc. who, after satisfactory completion of such terms as shall be deemed sufficient, indicate the characteristics described in the first paragraph,—a *Certificate as a Junior Craftsman*.

Guildsman. To those engaged in any of the Crafts, who have shown especial skill in developing the artistry or handicraft possibilities in their particular field of work, such as designing, laying off, modeling, carving, wrought-work, and have given visible evidences of individuality,—a *Certificate as a Guildsman*.

Architects and Engineers. To those, who have designed, specified and supervised buildings which have been successfully erected, who have shown knowledge of appropriateness of design with the most advantageous use of materials, who have encouraged pride of craft on the part of co-workers and have given individual recognition of it when deserved,—a *Certificate as a Master Craftsman*.

Builders and Sub-Contractors. To those who have satisfactorily either erected buildings or other structures or parts thereof, or installed equipment therein, and have encouraged pride of craft on the part of co-workers and have given individual recognition of it when deserved,—a *Certificate as a Cooperating Master Craftsman*.

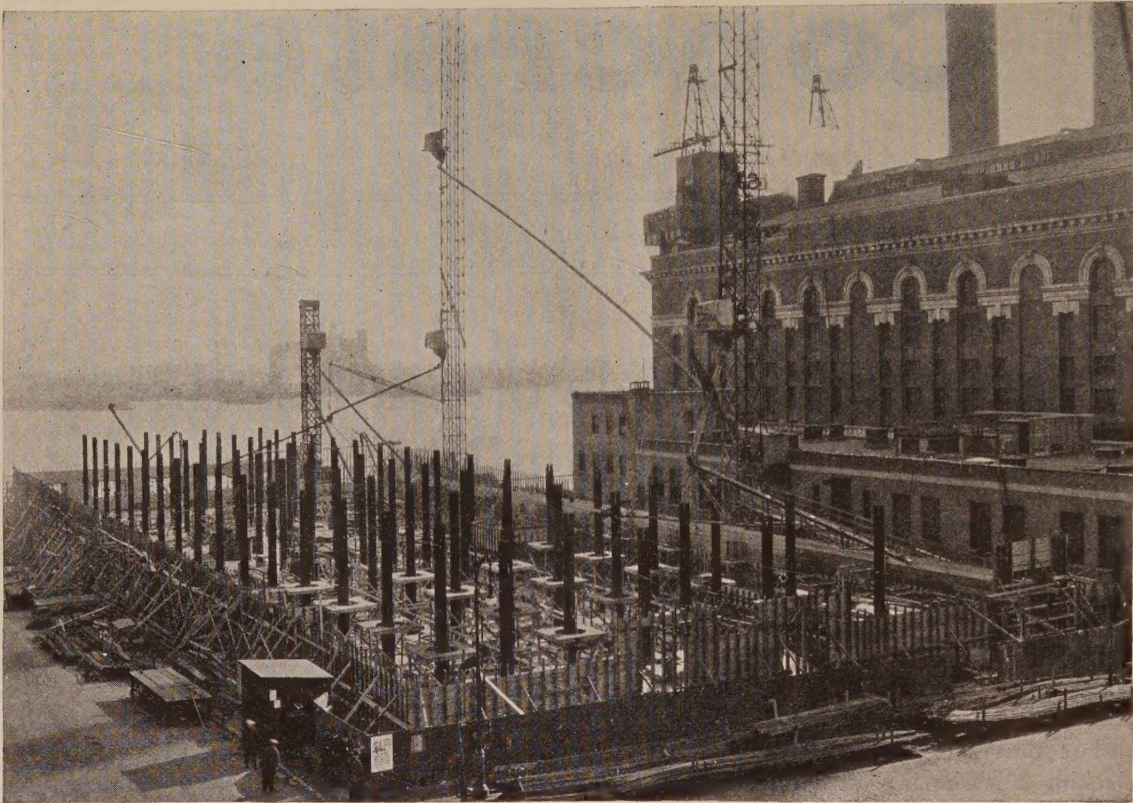


FIG. 1—HOISTING TOWERS IN POSITION FOR CONCRETING FIRST STORY; WALL FORMS AND PART OF BRACING FOR FIRST STORY COLUMN FORMS IN POSITION; STRUCTURAL STEEL COLUMN REINFORCEMENT ERECTED

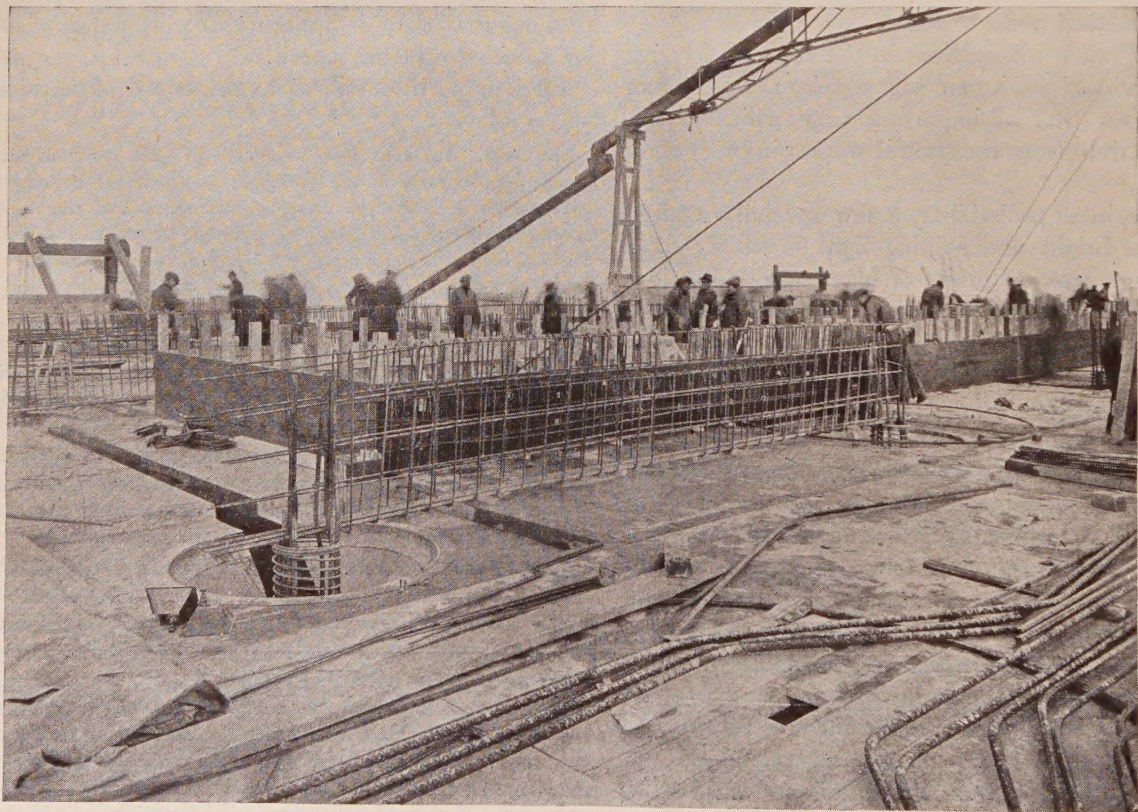


FIG. 2—DETAIL OF CHUTE FOR SPOUTING CONCRETE FROM HOISTING TOWER; ASSEMBLED REINFORCEMENT FOR FLOOR GIRDER ATTACHED TO COLUMN REINFORCEMENTS IN FOREGROUND, CONICAL STEEL FORM FOR COLUMN TOP AT LEFT

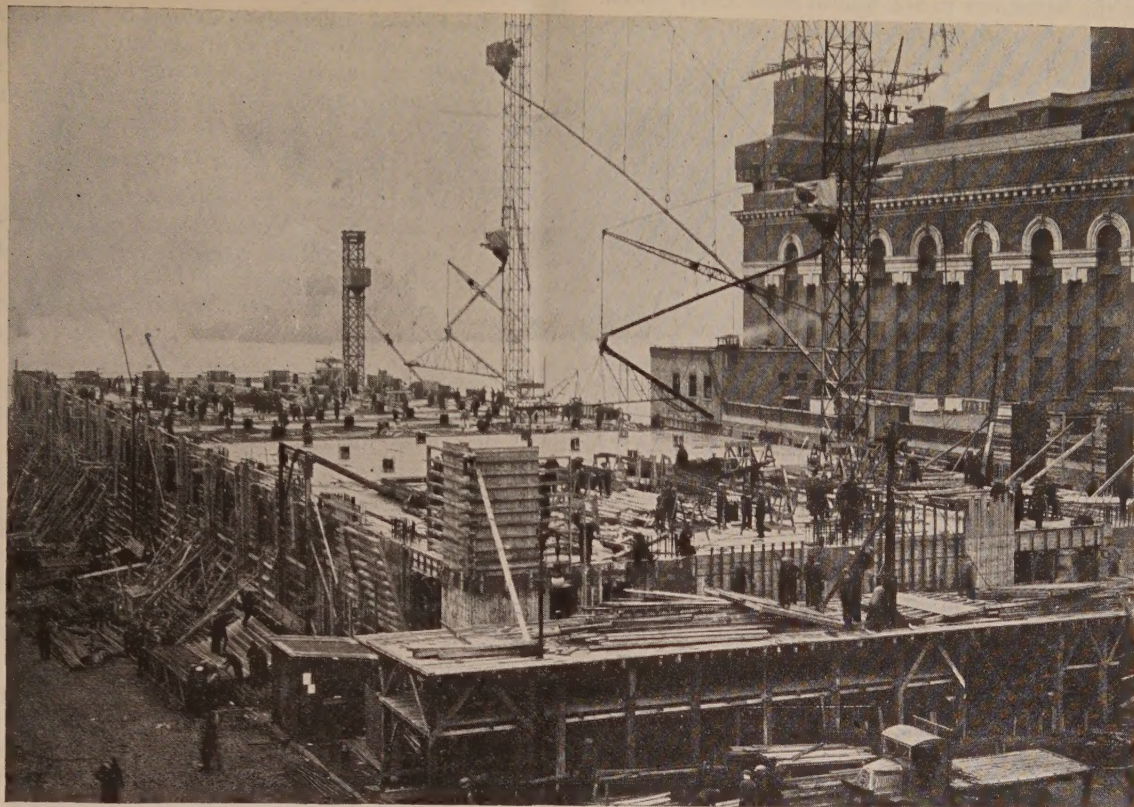


FIG. 3—CONCRETING THIRD FLOOR, SECOND FLOOR COLUMN REINFORCEMENT PROJECTING ABOVE SLAB TO BOND WITH UPPER STORY COLUMN REINFORCEMENT

Ten-Story Reinforced Concrete Service Building Erected One Story Per Week

BY FRANK W. SKINNER

The New York Edison Co. is now building at 41st St. and East River, Manhattan Borough, a \$2,500,000 reinforced concrete service building, about 150 ft. high, to provide convenient storage and classification for a large stock of supplies, for expeditious delivery, and for the service of several important departments of the organization. Standard steel forms for 680 columns and 470,000 sq. ft. of roof and floors installed with special shoring system saved much time, labor and material, permitting rapid, continuous work. Ample installation of steam and electric power appliances expedites operations.

The 115x414-ft. main building, ten stories high, with 23x140-ft. extension, two stories high, is equipped with electric cranes, trolleys, trucks, elevators, and other unloading and transporting apparatus. The lower three stories will be devoted to transportation service and automobile storage, and are advantageously entered on the north side of the building at the level of East 41st St., ascending from the river end of the building near the river front to the level of the third floor at the west end on the street line of First Ave., thus reducing the number of elevators required to four for freight and five for passenger service. The building and its equipment will provide for the service of the distribution and controllers departments which have

charge of all underground feeder systems, the meter and test department, the lamp department, the stationery department which requires 160,000 sq. ft. of floor space, and for various other purposes.

The plans for the design and equipment of this building were made by Thomas E. Murray, Inc., after a careful survey of service stations of public utilities in several large cities and, especially, of the structures and systems adopted by the United States Government, which handles the largest quantities of materials and equipment, and has enormous warehouses in Boston and New York, with capacities for \$20,000,000 and \$30,000,000 worth of goods, respectively. In accordance with this investigation, the building was designed on very simple standard lines, with circular columns 23 ft. apart longitudinally and transversely that support the flat slab, mushroom type floors proportioned to carry loads of 150 to 250 lb. per sq. ft.

The only special structural feature of detail is in the construction in the three lower stories, of 68 interior columns which, if of the ordinary reinforced concrete type, would have required maximum diameters of about 60 in. In order to minimize this obstruction, these columns have a special reinforcement consisting of a center core of riveted structural steel, about 50 ft.

high from the basement to the fourth floor level, which permits the exterior diameter of the column to be reduced to 32 in.

The structural steel core and grillages weigh 750 tons. The cores each consist of four pairs of flange angles riveted to web intersecting at right angles, and is enclosed by ordinary spiral and vertical reinforcement rods embedded in the solid concrete filling around the structural steel that is cast integral with the successive floors. Above the third story the column and floor construction is of the usual type.

The building will contain about 27,000 yds. of 1:1½:3 and 1:2:4 concrete, made with 200,000 bags of portland cement; about 25,000 yds. of high quality, fine graded gravel; and 12,500 yds. of sand, with more than 2000 tons of deformed reinforcement bars, chiefly ½ in. diameter for the floor construction and ⅝ to 1⅛ in. diameter for girders and columns. There were required about 6000 inserts,¹ 42,000 sq. ft. of steel window sash,² and 37,800 sq. ft. of window glass.

PRELIMINARY WORK

Operations were commenced June 1st, 1923, by the installation of four 1-yd. steam shovels that stripped from the irregular surface of the rock about 40,000 yds. of earth at the average rate of about 1100 yds. per 9-hr. day, although under favorable circumstances as much as 350 yds. per day were handled by a single shovel.

The shovels which delivered directly to 64 5- and 6-yd. Mack, Republic, and some other makes of motor trucks, also handled the 5115 yds. of rock excavated.

The rock excavation was carried down to a maximum depth of 16 ft. and to an average depth of 3½ ft. to the required subgrade level and to remove any soft or disintegrated rock. The rock was drilled with five jack-hammer drills, operated by an Ingersoll-Rand compressor,³ the holes being charged with 40% dynamite, of which about 5112 lbs. was used.

CONCRETE PILE FOUNDATION

At the west end, the original surface of the lot was above the elevation of the lowest floor, and the necessary excavation for the sub-structure provided sound rock bearing for the column foundation. At the eastern end, the dip of the rock surface downward towards the river carries it so far below the lowest floor level that special provisions were made for foundations on sound rock bearing. The bed rock is overlaid with river muck containing the remains of a large amount of old construction work, including timber cribs with stone fill, old brick walls, and even some iron or steel tanks. The obstructions were such that wooden piles could not penetrate them, and open or cofferdam excavation below water level was practically impossible. It was therefore decided to drive hollow steel cylinder piles to solid rock bearing, at a cost estimated at not more than one-third as much as would be necessary for pneumatic caissons and at twice as great rapidity as the latter could be sunk. The contract for this work was therefore awarded to Spencer, White & Prentice who, with a force of about 30 men, completed the foundation in 40 working days without interfering with the work simultaneously progressing at the other end of the lot.

There are 39 columns with average loads of 900 tons each that are supported on 303 concrete-filled steel piles from 15 to 50 ft. long. A typical pier consists of nine piles with steel shells 16 in. in diameter and

7/16 in. thick. These were received in lengths of about 20 ft. and spliced together as driven by inside tapered sleeves having a diameter 1/16 in. greater than required for a driving jib, and thus securing absolutely watertight side joints. Each pier is capped by a heavily reinforced concrete footing 4 ft. thick.

DIFFICULT PILE DRIVING

The piles were driven to within a few inches of the rock surface by a No. 2 Vulcan steam hammer⁴ operating in the lead of an ordinary pile driver tower. Driving was severe, requiring upward of 1500 blows, according to the length of pile and the obstruction encountered. It was performed so successfully that where there was occasion to recover some of the piles, they were found to have cut through solid brick walls, heavy timbers, and masses of concrete, producing cores as solid as those of a diamond drill borings.

The pile driving was followed by a rolling derrick equipped with No. 7 McKiernan Terry hammer,⁵ with which the pile was driven from a few inches to 2 ft. to satisfactory bearing on sound rock. The contents of the pipe was blown out with air pressure, and after the bearing was tested and examined, the cylinder was filled with 1:2:4 concrete, mixed in an electrically driven Smith machine.⁶

The air was compressed in a battery consisting of one Ingersoll-Rand Imperial No. 10 compressor³ with a capacity of 550 cu. ft., 220-ft. and one 150-ft. National Air Brake compressor,⁷ all of them driven by Westinghouse motors⁸ and furnishing air to operate the steam hammers and the 35-h. p. double drum and swinger Lambert steam hoist.⁹ The 50-h. p. Lidgerwood hoisting engine¹⁰ on the derrick was operated by an attached electric motor. The cylinders were cut off at the required elevation by a K.-G. Welding & Cutting Co.'s oxy-hydrogen torch¹¹ that did the work accurately and rapidly, only a few minutes being required for each pile. About 9000 lineal ft. of cylinders were driven in very accurate alignment and location, and provided a satisfactory solution to a difficult foundation problem.

Sand, gravel, cement, and some steel were received on barges at the pier at the end of the building. All other materials and plant were delivered by trucks and stored on the site of the building and on both sides and at the river end where large quantities of timber, reinforcement steel and steel forms were piled and where carpenter work, rod bending, and other operations were carried on.

The aggregate was delivered in 500-yd. barges that were required to be unloaded very rapidly so as not to obstruct the pier, which was in daily service for unloading coal and for other purposes; therefore, two stiff-leg derricks with 30 ft. booms, installed on the pier, were each equipped with a counterbalanced 1-yd. Blaw-Knox dreadnought clamshell bucket,¹² designed to combine maximum digging power with high-speed operation and each having a capacity to handle 100 yds. of sand or gravel per hour. The sand bucket is operated by a 3-drum, 3-spool Lambert hoisting engine with swinging gear, the gravel bucket is operated by 3-drum, 3-spool Lidgerwood hoisting engine and swinging gear;¹⁰ both engines using steam from a 2½-in. line from the adjoining station.

⁴Vulcan Iron Works, Chicago, Ill.

⁵McKiernan Terry Drill Co., New York City.

⁶T. L. Smith Co., Milwaukee, Wis.

⁷National Brake & Electric Co., Milwaukee, Wis.

⁸Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

⁹Lambert Hoisting Engine Co., Newark, N. J.

¹⁰Lidgerwood Mfg. Co., New York City.

¹¹K.-G. Welding & Cutting Co., New York City.

¹²Blaw-Knox Co., Hoboken, Pa.

¹Dayton Concrete Steel Co., Dayton, Ohio.

²Detroit Steel Products Co., Detroit, Mich.

³Ingersoll-Rand Co., New York City.

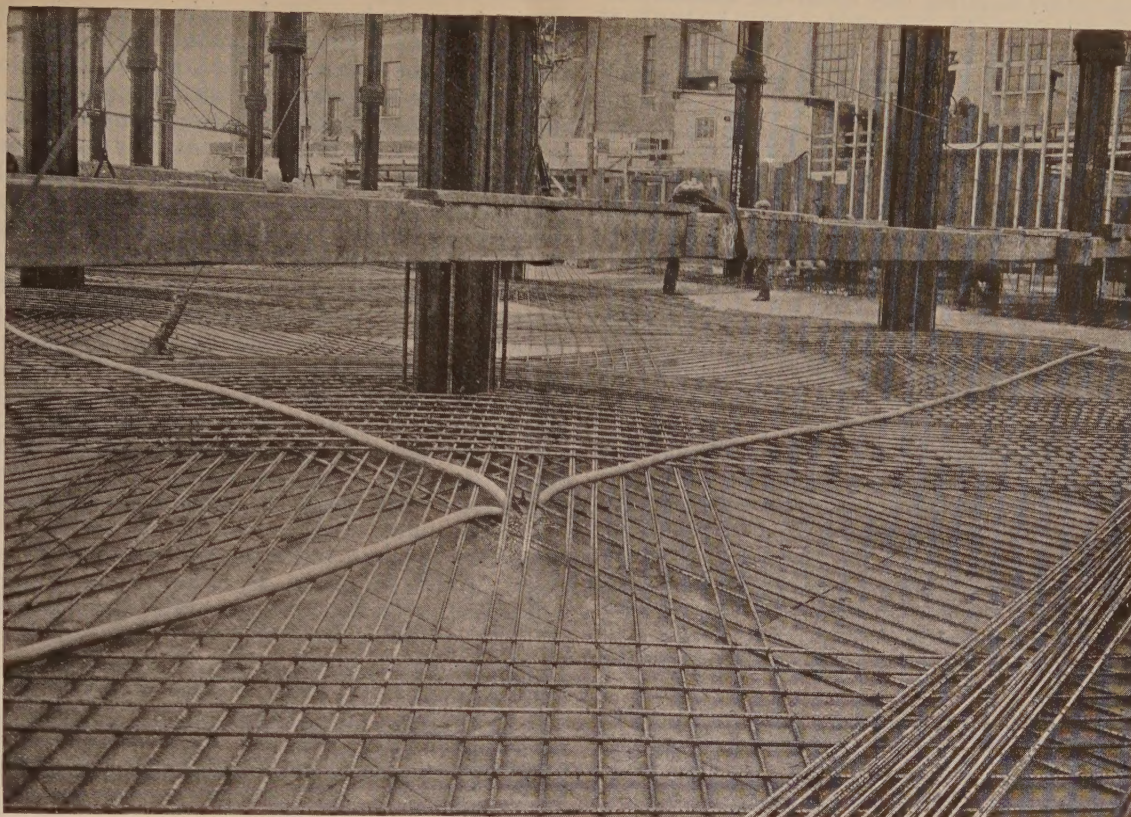


FIG. 4—ARRANGEMENT OF REINFORCEMENT STEEL IN FLOOR SLAB AND POSITION OF CONDUIT TUBES

CONCRETE PLANT

In order to conform to a rigid schedule of operations that provided for rapid and continuous work, the beginning and completion of successive operations were carefully dated in advance, and the organization, equipment, and supplies were arranged to provide for each without delays or interference. The Kenn-Well Contracting Co., a general contractor for the building, installed a very complete and efficient concrete plant with a rated capacity of 400 yds. per 8-hr. shift, which was designed in conference with the R. E. Brooks Co.

This installation consisted of standard apparatus, operated by General Electric motors¹³ and arranged to provide for continuity of service with a minimum of hand labor, enabling an average of 2500 yds. of concrete for the floors, walls, and columns of one story to be laid in six days by a regular force of 650 men, including those who unloaded the aggregate and cement, operated the storing and conveying mechanism and the concrete mixer and the distributing system by which it was spouted to position in the forms.

Sand and gravel were unloaded from the barges into bulkhead storage bins of about 1000 and 1200-yd. capacity, respectively, that were built on the pier floor with outwardly inclined, exterior braced, wooden walls about 20 ft. high. The two bins were separated by a double bulkhead wall transverse to the pier that provided, on its center line, a tunnel in which was installed a 30-in. horizontal belt conveyor 70 ft. long. An attendant in the tunnel operated eight bin gates placed in the opposite sides of the walls to deliver sand or gravel to the belt conveyor as signalled by the storage bin attendant. The belt, driven by a 10-h. p. General Electric motor,¹³ delivered to a 40-ft. bucket conveyor, with a capacity of 90 yds. per hour, which elevated the aggregate 35 ft.

to the mixer bin of 100 yds. combined capacity and operated by a 15-h. p. motor.

The cement barges were unloaded by a slat conveyor 70 ft. long, and the cement was stored in a shed of 10,000 bags capacity, on the center line of which there was installed another slat conveyor 80 ft. long, driven by a 10-h. p. motor that delivered the cement bags to the mixer platform, where they were unloaded by hand and emptied as required into the charging hopper, which was supplied with sand and gravel through mechanical measuring devices. The 1-yd. concrete mixer, driven by a 25-h. p. motor, was controlled by another man who, with the three men in the cement shed, constituted the entire mixing force.

Owing to the restrictions for space and storage, it was impracticable to locate the concrete distributing plant adjacent to the necessary site for the aggregate storage and mixing, and the hoisting towers were installed at about the one-quarter point, 200 ft. apart, on the long south side of the building in a narrow space only 19 ft. wide, between it and an adjacent building.

The mixer discharges into a hoisting bucket in a wooden tower 98 ft. high. From this tower, material is spouted directly to the east end of the building and, when necessary, relayed to the 240-ft. Insley relay tower¹⁴ serving the west end of the building. Each of the three towers is equipped with a 1-yd. hoisting bucket, operated at a speed of about 350 ft. per min. by a 100-h. p. hoisting engine driven by a General Electric motor. Each of the steel towers is equipped with a sliding frame, carrying a receiving hopper, a 50-ft. boom, a 50-ft. counterweight truss, and two 30 ft. swivel-head steel chutes, giving a distributing radius of 110 ft. that enables the two towers to command the

¹³General Electric Co., Schenectady, N. Y.

¹⁴Insley Mfg. Co., Indianapolis, Ind.

entire area of the building and spout the concrete to any required point. The chutes have an inclination of about one on three, which enables the concrete to flow freely without the addition of lime or any other lubricant.

WALL, COLUMN AND FLOOR FORMS

The walls, beams, and all rectangular columns are concreted in simple wooden forms, the construction of which required about 650,000 ft. board measure of dressed tongue and groove lumber and rough lumber for bracing. The large surfaces of the wall forms were, in general, made with uniform 4x15-ft. panels that were shifted from place to place and used many times. A force of from 150 to 225 carpenters and assistants were required constantly to make, repair, clean, and shift them.

The floors and interior column forms were centered by The Building Products Co., Toledo, O., using the Blaw-Knox system of standard steel form and shoring,¹² which was selected and installed so as to provide for very rapid, continuous service and the repeated re-use of the equipment, which included about 90,000 sq. ft. of flat slab floor forms, enough for two stories; column forms for one and one-half stories; drop heads and column guards for three stories; and timber shores for two and one-half stories.

The floor forms were assembled with rectangular units of 14 gauge pressed steel, stiffened with interior ribs and having standard widths of 12, 18, and 24 in. and lengths of 4 ft. and 6 ft., thus making convenient sizes easily handled and with which any required panel dimensions could be made. The sectional column forms, the conical column capitals 5 ft. in diameter, and the lower story column guards about 5½ ft. high and 32 in. in diameter were made of No. 10 gauge steel.

The first floor concrete was laid on the graded bottom of the excavation, and after it was sufficiently hard, one story falsework towers were set upon the centers of the 68 columns, and were very carefully leveled, centered, and braced to establish the elevations and locations of the floor panels. Each tower was made with four 4 x 4-in. corner verticals and carried an 8x8-ft. wooden platform pierced with a circular hole for the column capital and having abundant clearance for the structural steel reinforcement core 50 ft. high that had been previously erected in position.

Between these towers and braced to them by horizontal wooden struts, there were set 4 x 4-in. vertical shores at the intersection of transverse and longitudinal lines about 6 ft. apart. These shores were provided at the upper ends with shoulders on opposite sides to receive 2x8-in. removable stringers that were held in place by wooden scabs pivoted on single bolts through the shores, that enabled them to be revolved into horizontal positions and clear the stringers, or back to vertical positions locking the latter in place.

The shores were seated on folding wooden wedges, and the stringers were seated on adjustment wedges, enabling them to be accurately levelled, thus insuring a perfect and uniform horizontal surface for the steel form pans that rested on the stringers. This system eliminated the use of nails, screws, and bolts for the erection of the shores and stringers, excepting the comparatively few nails used for the ribbon bracing. The falsework provided uniform, standard units, made in advance, and that could be assembled, adjusted, shifted, and reassembled with the minimum time and labor.

After the floor concrete was poured and sufficiently hardened, light, movable towers or tables were set under the floor panels, between shores, and after about

two or three days of good weather, about 80% of the shores were slacked off by driving out the bottom wedges and were removed, permitting the floor pans, which were not fastened to the stringers, to be lowered to the towers and easily handled for cleaning, oiling, and re-erection. Lines of shores, about 5 ft. apart on centers, were, with the floor pans they supported, left undisturbed to carry the floors from 10 to 30 days longer until they had developed abundant strength for complete self support, and shores and pans were removed for re-use in upper stories.

The shores, column towers, and steel forms were erected, stripped, shifted, and re-erected at the rate of one complete story per week, with a total force of 90 to 100 men, including 40 carpenters, 10 or 15 sheet metal workers, and about 40 laborers, especially trained for this service so that each man performed certain specific duties over and over again until he was very expert in them and responsible for accuracy and promptness that made the work very satisfactory.

It is estimated that in this job the timber required for shores, bracing, and connections amounted to only about 1½ ft. B. M. per sq. ft. of floor area, as compared with 3½ ft. of lumber required for an all-wood form job. In addition, there is a very high salvage value for the standard shores, braces, and steel forms which have sustained very little damage or depletion at the end of the job. The column and ceiling finish is very smooth and attractive, and the obstruction and fire hazard of the shoring and form timber is much reduced by the use of the steel pans and column forms.

REINFORCEMENT

Reinforcement bars for special girders and the circular bars for the column capitals were cut and bent by hand at the building. The spacing bars and the ⅝-in. spiral column hooping were machine-bent at the mill. The floor slab reinforcement, consisting of light, straight bars, was laid on concrete filler blocks, elevating it about 1 in. above the steel form pans, and was wired together at intersections in the usual manner. The blocks were made in 8-ft. lengths in wooden, open, form troughs about 10 or 12 ft. long, and were broken into shorter pieces as required when used.

The hooping was received in close coils that for the lower three stories were securely fastened at the lower end to the bottom of the previously erected steel cores, or to the finished construction. On opposite sides of the upper end, there were attached two-part tackles suspended from 6x4-in. wooden gin poles about 15 ft. long, with their lower ends knee-braced to short horizontal sills. These gin poles were set in opposite sides of the columns in a slightly inclined position, with their upper ends resting against each other or against the column core. These tackles, rove with about 100 ft. of ½-in. steel cable, were simultaneously operated by small Sasgen hand windlasses,¹⁵ with double cranks attached to the gin poles. The hooping coils were thus stretched vertically upwards to their required pitch and engaged the spacing bars that hold them in position. The work was rapidly and easily accomplished by 18 or 20 gin poles and windlasses. Above the third story, where the columns were reinforced by bars instead of structural steel cores, the spiral hooping was extended to the required length and secured to the spacing bars while supported on work benches from which the finished spirals were taken to the column forms and set in place.

GENERAL EQUIPMENT

The lumber was bored and cut to lengths by machines operated by a 10-h. p. electric motor. The cement bags

¹⁵Sasgen Derrick Co., Chicago, Ill.

were cleaned by a machine operated by a ½-h. p. electric motor. Water pressure for fire protection was provided by a 6½x8-in. plunger pump with a 4-in. discharge, operated by a 5-h. p. electric motor. The excavation was drained by a gasoline-driven Domestic 2-h. p. diaphragm pump¹⁶ with 4-in. discharge, mounted on a truck.

Concreting was uninterrupted by cold weather, protection from frost being provided by enclosing the wall openings in the upper story by tarpaulins, and by covering the upper floor with tarpaulins about 2 ft. above floor level to retain the heat from about 50 coke burning salamanders set on the floor.

The aggregate storage piles were heated by perforated steam pipes laid in horizontal wooden boxes about 5 ft. apart under the piles. Steam coils carried around the insides of the supply bins over the mixer, kept the sand and gravel there always warm enough so that the mixing was uninterrupted on account of frost, and no hot water or salt was required in the concrete.

Effect of Storage of Cement

A second edition of Bulletin No. 6, of the Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill., of the effect of storage of cement has just been issued and the text entirely rewritten. Although no important changes in the original conclusions have been made necessary by the addition of the later tests, the tables have been revised to include tests for the two-year and five-year storage periods. The principal conclusions from a preliminary study of the data from an investigation of bin-stored cements are included, and a comprehensive bibliography on storage of cement has been added.

The following summary by Duff A. Abrams, is taken from the revised bulletin:

Tests were made in order to determine the concrete and mortar-making properties of 3 different lots of portland cement which had been stored up to 5 yr. in sacks under different conditions. The cements were purchased from dealers' warehouses and stored in the Testing Laboratory, in the basement of Lewis Institute, and in a shed in the yard for 2 yr. After 2 yr. all cements were stored in the Laboratory. In general, the cement was stored in lots of 800 to 1200 lb. in standard cotton sacks; in one group of tests 2 brands of paper sacks were also used; in another group the cloth sacks were covered with thin layers of hydrated lime and portland cement. Upon receipt of the cement, and after storage for 3 mo., 6 mo., 1, 2, and 5 yr., concrete and mortar specimens were made for test at ages of 7 and 28 days, 6 mo., and 1 and 2 yr. The tests were begun November, 1916, and completed November, 1923.

This report includes compression tests of about 1250 6 x 12-in. concrete cylinders, 1300 2 x 4-in. cylinders of 1:3 standard-sand mortar, and about 500 miscellaneous tests.

The following are the principal conclusions from this investigation:

1. The average strength of the concrete (mix, 1:5 by volume, relative consistency 1.00 tested in 6 x 12-in. cylinders, cured in a damp condition) made from the cement as received was 1470 lb. per sq. in. at 7 days; 3020 at 28 days; 4410 at 3 mo.; 4680 at 1 yr.; 4910 at 2 yr.; and 6030 at 5 yr. The increase in strength of concrete with age shown by these tests was approximately proportional to the logarithm of the age, which is characteristic of concrete cured in a damp place.

2. There was an appreciable loss in strength of portland cement due to storage in small lots in sacks for all conditions covered by these tests; the loss was greatest for the cements stored in the shed, and least for those stored in the Laboratory. Basement storage was almost as severe as outdoors. The loss in strength was greater for the first 3 mo. of storage than for later 3-mo. periods. For example, the 28-day tests for cement stored in shed showed a loss of about 500 lb. per sq. in. for the first 3-mo. storage and about 250 lb. for the second 3 mo. Still smaller losses were found for later 3-mo. periods. In general, the concrete strengths for the cements stored in the shed 1 yr. and longer were about 80% of those for cement stored in the Laboratory. The deterioration shown by

these tests was probably greater than would be found in a larger lot of cement stored in sacks under similar conditions.¹

3. The effect of storage of cement was found to be largely a question of the age at which concrete or mortar tests were made. The early tests showed a much greater loss in strength due to storage of cement than tests at later ages. It is of the utmost importance that the strength of the cement was not permanently reduced as shown by the early tests; cements stored in shed for 3 mo. gave an average "strength-ratio" of 73% (as compared to the original strength of concrete) when tested at 7 days, 75% at 28 days, and 84% when tested at 6 mo. to 2 yr. Similar relations were found for the other conditions of storage. (See Table 10 and Fig. 3.)

4. After storage of cement in shed for 3 mo., the average strength-ratio for the ages at which tests were made was 80%; after storage for 6 mo., 72%; 1 yr., 60%; 2 yr., 46% and 4½ yr., 45%. (See Tables 10 and 11 and Fig. 3.)

5. Two brands of paper cement sacks gave results which did not differ materially from cloth sacks when used for storing cement for periods up to 4½ yr. (See Table 12.)

6. A thin covering of portland cement or hydrated lime over cement in cloth sacks showed some advantage, but not sufficient to justify the cost of this method of storage. (Table 13.)

7. There was no essential discrepancy between the indications of the compression tests of 1:5 concrete in the form of 6 x 12-in. cylinders and the tests of 1:3 standard-sand mortar in 2 x 4-in. cylinders.

8. The time of setting of cement increased up to storage periods of 1 or 2 yr., and decreased for the longer periods. At the beginning of the tests, the initial time of setting was about 4½ hr., after storage for 1 yr. about 7 hr.; for final time of setting the corresponding values were about 8 and 12 hr. (Table 2 and Fig. 11.)

9. The normal consistency of cement was only slightly affected by storage up to 2 yr.

10. It appears that the deterioration of cement in storage is due to absorption of atmospheric moisture, which causes a partial hydration, which in turn, exhibits itself in the lower strength-ratios for concrete, particularly at the early ages.

11. Only a negligible quantity of lumps formed up to 1-yr. storage; these were soft and readily broken. The lumps found in the sacks after storage for 2 yr. and over were generally quite hard; in the shed-stored cements lumps amounted to as much as 30 to 75% of the cement. Lumps were generally discarded before testing the cement.

Concrete and mortar tests of cement and pulverized lumps from cement stored for 7 yr. showed the cement to have about 30% of its normal strength, and the lumps 35% of the strength of the cement; in other words, the "lump cement" gave 10% of the original concrete strength. For these tests the lumps were pulverized to such a fineness that all passed a 28-mesh sieve, and about 45% was retained on a 200 sieve. Earlier tests of broken lumps screened from cement and tested shortly after it was received at the Laboratory gave strengths in concrete about 50% of that made with cement from the same sacks.

Slag as an Aggregate

At a recent conference of the National Slag Association held at the Bureau of Standards, Washington, J. C. Pearson, formerly chief of the Bureau's cement section, told the conference about tests made at the Bureau of Standards on the properties of concrete in which slag is used as aggregate. The Bureau finds that if the usual properties are adhered to, the concrete made with slag is less workable than that made with gravel, and is not so easily handled, but this difficulty can be avoided by using a larger proportion of sand. Strength tests are now under way, it was reported, and results are expected in the near future. The slag concrete is found to fill about 6 or 7% less space for the same volume of aggregate as compared with gravel concrete, according to Mr. Pearson.

It was pointed out that there are twenty million tons of slag produced annually in the United States, and that it sells for a small fraction of a cent per lb. It is usually not handled by the steel industry, but is sold by steel manufacturers to independent concerns who make it into useful products.

¹Tests on bin-stored cement now under way have shown an increase in concrete and mortar strength for 4-mo. storage particularly in the 7 and 28-day tests; beyond this time a decrease was found, but up to 1½-yr. storage the strength of the cement had not, in general, decreased below that obtained in the initial tests, which were made only a few days after grinding the cement.

The Development of Cinder Concrete Building Units

¶ Notes on Patents, 1867 to 1923—Processes and Early Tests

¶ Francis J. Straub—His Patent—The Use of "Whole Cinders"—Manufacturing Success—Fire Tests

¶ Sigurd Bo and the Bo Process of Making Units From "Purified Cinders"

¶ Future Standardization and Quality Control

An attempt to answer many inquiries as to the ins and outs of using cinder aggregates in making concrete building units

BY HARVEY WHIPPLE
Editor CONCRETE

The most important development of masonry building units in recent years is unquestionably in the use of cinder concrete.

In little more than half a dozen years the cinder product has come out of the obscurity of isolated manufacture and use to an annual output in 1923 equivalent in wall volume to approximately 600,000,000 brick.

The importance of the cinder concrete building unit springs from numerous factors.

It utilizes as the principal ingredient a waste material. Cinders have not only been to a very great extent useless, but often less than useless, since their disposal has involved expensive handling.

Cinders are highly cellular and as an aggregate in concrete provide a unit very light in weight and easily handled. This same characteristic is valuable for other reasons.

Cinder concrete units provide excellent bond for stucco, plaster and mortar.

Being highly cellular they provide good temperature insulation.

While being of a cellular structure they have a low capillarity and other things being equal, they probably absorb less water than a fairly good concrete with a sand aggregate under weather exposure.

They have a very satisfactory resistance to fire; sometimes an exceedingly high fire resistance. An average product has undoubtedly a better fire endurance value than average units of gravel or stone concrete.

Not the least of their special attributes is nailability; grounds, frames and trim may be nailed directly to cinder concrete building units. The units do not crack under this treatment and the nails hold as in wood.

Being light in weight (30 lbs. for an 8x8x16 unit, as against 50 lbs. for an average unit of other aggregates) cinder unit haulage is cheaper. Units are handled on the job more easily and therefore more rapidly.

Thus cinder units indicate a very considerable economic advantage at each step—made of an aggregate which is waste material, light and easy to handle, cellular, providing good insulation and excellent mechanical bond and having a high fire resistance.

It is not surprising that in these last half dozen years the cinder unit has made such rapid progress. It may be surprising that a large development did not

come much sooner, especially as cinders have for many years been employed as concrete aggregate for precast units and for reinforced and mass concrete cast in place. The material's light weight and fire resistive qualities have long been recognized for floor construction. In precast units it has been used in Europe for many years. In America it has been made into blocks for more than 10 years (practically continuous production in one plant) with scattered evidence of recognition by numerous experimenters over a much longer time. As early as 1904 Ira H. Woolson, consulting engineer of the National Board of Fire Underwriters, at that time in charge of the testing laboratory at Columbia University, made tests of partition blocks for M. M. Marsden of Manayunk, Pa. The block were made of cinders, ashes, plaster and cement. Mr. Woolson made other tests in 1907 for James W. McKinnon of Rutherford, N. J., on partition blocks made of a mixture as follows: 1 part cement, 1 part plaster of paris, 3½ cinders.

Why, then, has the development been so slow?

Because, as in many other instances of important industrial development, an achievement of this kind depends upon other things. It waits for a favorable economic situation and for the appearance of someone who, adding to the faculties of the inventor, can go up and down the country and sell the idea.

To conceive an idea is one thing; to apply it in a small local way is the next step; to sell the idea and to induce others to put capital behind it and carry out convincing tests of its value; to put the idea on the industrial map over a thousand miles of territory—this is another thing. This in itself is an achievement which is entitled to its reward.

Such achievement involves certain patent rights. As a means of reward for such achievement the Government, through the patent office, gives to the originator of an idea the exclusive use of it for a term of years during which he may say who shall use that idea and on what terms. A patent establishes a monopoly. To secure a patent is only the beginning. A patent must often be defended against many comers—some who set up that the idea isn't new, that it has been successful in commercial application prior to the patent.

There is something inherent in the public disposition

which abhors a monopoly. Few pay any particular attention to it until it achieves commercial success; then a great many people want to use it. They frequently try to use it without paying tribute.

That is the situation with cinder concrete building units. The magazine CONCRETE receives numerous inquiries about this concrete block, brick and tile.

Is the Straub patent valid?

What about the Bo patent?

Must I pay a royalty if I make such a concrete building unit?

Why should I pay royalty when the product was made long before Straub or Bo got patents?

And so on.

The magazine CONCRETE has no legal standing as a court of justice. It would be the height of folly to attempt to "hand down a decision" with respect to the cinder concrete products situation. It will have to work itself out. It *will* work itself out because it is economically important. In the meantime there are certain outstanding features of the situation which lend themselves to plain statements of fact—facts, to the extent of the writer's knowledge and belief. These are published here as a contribution to progress in a branch of the concrete industry which to a considerable extent is being affected by two things—

1. The status of patent rights affecting the use of cinder concrete.

2. The inclination and the ability of the owners of certain patent rights to enforce them, not only in the collection of fees and royalties but in the maintenance of acceptable standards of quality in the products.

In a survey of the cinder products situation certain fundamental considerations affect the writer's view of that situation. It seems only fair to the reader that he know at the outset what these fundamental considerations are:

1. That development of cinder concrete building units is desirable which gives to the greatest number of people in the shortest possible time, the fullest and most satisfactory use of an economic building advantage.

2. The men whose originality, talents, inventiveness, aggressiveness and perseverance are largely responsible for giving the public an economic building advantage, are entitled to an appropriate reward. This is in the public interest—so that other men may have the incentive to work for the general good.

3. It is in the public interest that the owner of a patent right who has numerous licensees paying for the privilege of using that patent—first, make provision for the enforcement of his monopoly; second, provide for the maintenance of such quality in the product as will insure to the public a reasonably full realization of the advantages of the patent.

4. Monopolistic control under a patent *may* work decidedly in favor of the public.

The whole concrete building unit business, irrespective of the aggregate used, *might* much sooner have attained a large economic importance if from the first it had been developed under a monopoly. A wise and progressive monopoly would have eliminated the backlot operator and financed the research necessary to produce the best and most economical product.

5. If patent control falls into evil ways and does not consistently insure to the public those benefits which are the basis of a monopolistic award it is in the public interest that some development of the basic idea be sought which will insure those public benefits regardless of individual losses or profits.

Let us first examine a little of the history of the cinder concrete building unit.

Historical Notes on Use of Cinders in Concrete and Patents From 1867 to 1923

The use of hydraulic cement dates as we know to the time of John Smeaton and the building of the Eddystone Lighthouse. The manufacture of hydraulic cement in this country was approximately coincidental with the construction of the old Erie Canal across New York State and from that time we reckon the use of concrete in this country.

Sand and crushed stone were the natural aggregates to be employed in mixing of concrete with the old Rosendale natural cement. An appreciation of the convenience of being able to *mould* masonry units, however, instead of having to quarry them was probably a collateral offshoot of the first uses of cement. Such units were, of course, of approximately the same weight as natural stone and it was evident that their usefulness could be still further enhanced if some means could be found for reducing their weight, as well as their cost. It was natural to turn for this purpose to the use of cinders, which could be had for the asking, and which were certainly lighter than crushed stone.

In 1867 a patent, No. 61984, was issued to Messrs. Baldwin, Gibbs and Jones. The patent covered:

"A cement for walks, cellar bottoms, barnyards, etc. formed by the combination of coal tar, coal pitch, sand, coal ashes or coke, furnace cinders or iron scale, and Rosendale cement"

A slightly later patent, No. 89311, was issued to George Heim, in 1869, on the admixture of

1 part stone lime
1 part water-lime or cement
4—8 parts coal ashes and coal dust
2 lbs. potash per bu. of cement
Water to form a plastic mixture

A cinder concrete bearing a resemblance to the product we know today is specified in the Joseph A. Shinn patent, No. 280679, issued in 1883. We read:

80%—90% of coal ashes
20%—10% of lime or its equivalent

"by the term ashes herein used is meant the ash which is the residue of the combustion of coal. The coal and coke may be removed by screening."

Herein we find a definition of "ashes," the permissible substitute of an equivalent (cement) for the lime as a binder, and the interesting sentence "The coal and coke may be removed by screening." This may be construed either as a tacit acknowledgement that screening is desirable, or as an admission that it is also not strictly necessary to the success of the formula.

In 1885 a patent, No. 322559, was issued to Ernest L. Ransome. Ransome defines "ashes" and makes two important points:

The term ashes includes all waste products derived from the combustion of fuel in shops, factories, dwellings and other places where fuel is burned.

By screening the fine ashes are separated from the larger particles, called the cinders. These cinders may be crushed and recombined with the screenings. However, when a fireproof, enduring brick is desired, the "cinders" should be reburned, thereby consuming the coke which they contain.

The coal ashes should be washed before being used in order to eliminate soluble salts. The coal ashes, mixed with the lime obtained from the burning of limestone, or with cement, are molded under heavy pressure.

This patent it will be noted makes provision for the screening and recombining of the ashes, and suggests the advisability of washing the coal ashes before using in order to eliminate soluble salts.

A later patent (1893) No. 509924 was given John Lorenz on a formula consisting of

"20 parts ashes
15 parts cinders
2 parts burned sand
Several parts cement
Water."

Additional patents in which the term "cinders" is still further defined and covering the use of cinders, sand, and other materials were granted in 1898, No. 614635, and 1904, No. 770,557, to Harry F. Ingerson and C. W. Brunson, respectively.

Patent No. 828041 was granted to Mark W. Marsden, in 1906 on the use of

"unconsumed coal, clinkers and ashes, being the residue of the combination of anthracite or bituminous coal or coke, ground to pass No. 30 screen and mixed with cement and gypsum."

Grosvenor Atterbury, architect, was granted a patent, No. 1163060, in 1915 for

"160 parts of cinders crushed to $\frac{1}{4}$ in.

133 parts of short asbestos fibre

100 parts hydraulic cement."

The writer recalls having talked with Mr. Atterbury at about the time of this patent, in the course of a visit to Mr. Atterbury's "house building laboratory" at Forest Hills Gardens. Mr. Atterbury spoke of the special concrete for its fire resistance and nailability.

Francis J. Straub, New Kensington, Pa., made application for a patent on cinder concrete building units in 1915 and patent No. 1212940 was granted January 16, 1917. The patent provides:

"The ground mixture of cinders retains all of the usual accompanying adhering portions of the cinders in the resulting product, and it is essential that the original mass of cinders and ashes as it comes from the furnace, grate bars, or other source remains in the resulting mixture without separation or change of proportions."

The patent makes no mention of screening and recombining, the addition of sand or other material, or the removal of any part of the mass. These phases of the use of cinders were at least partially covered by other patents.

Subsequently the Patent Office issued patents Nos. 1,218,239, 1,279,119 and 1,317,288 to Messrs. Frank Cordery, Wilson U. Jury, and Leo Helper, respectively. These cover cinders, cement, and the admixture of colored earth, hydrated lime, sand and crushed stone, etc.

Aug. 28, 1923, patent No. 1,466,083 was issued to Sigurd Bo for a process of cinder purification which is the basis claimed for Bo cinder concrete products.

A miscellany of notes in further reference to manufacture, test and use of cinder concrete building units discloses an interesting and easily overlooked item of freight classification and rate on cinder brick 35 years ago.

A letter from the official Classification Committee by O. F. Lovenberg, secretary, 143 Liberty Street, New York City, reports the existence of a freight classification for cinder brick more than 35 years ago. Mr. Lovenberg says in part:

This specification appeared in item 30, page 53 of Official Classification No. 37 which Classification was in effect January 1, 1911. The entry first appeared in Official Classification No. 3, effective Feb. 1, 1888, but the Official Classification Committee's records do not go back that far and we have no information as to the manufacture of brick. Our records, however, do indicate that these brick were formerly manufactured in the Mahoning and Shenango Valleys and also at Hamilton, Ohio, and that the manufacture in those districts had been discontinued which resulted in elimination of the specification from the Classification.

Dec. 12, 1904, Ira H. Woolson, then in charge of the Testing Laboratory at Columbia University, made a fire test upon some partition blocks for M. W. Marsden, of Manayunk, Pa. These blocks were of different thicknesses about 2 feet long, and probably 15 or 16 inches wide. They were composed of ground cinders and ashes cemented together with a certain proportion of plaster and cement, with some additional binder, claimed as a secret by the manufacturer.

Oct. 22, 1907, Professor Woolson made a test upon similar partition blocks for James W. McKinnon, of 107 Mountain Way, Rutherford, N. J. These blocks were composed of materials proportioned as follows:

Cement 1, plaster of paris 1, Holland white $1\frac{1}{2}$, and cinders $3\frac{1}{2}$.

Both of these tests gave very good results, but to what extent either of the blocks has been used commercially Professor Woolson does not know.

In addition to these, Professor Woolson made a large number of tests of so-called "cinder plaster blocks" which in most cases were composed principally of cinders cemented together with gypsum plaster.

After Professor Woolson left the laboratory, one of his assistants, conducted a test for H. W. Bell, 2582 Park Ave., New York City, on cinder partition blocks composed of 1:7 mixture of cement and cinders, the latter being composed of both coarse and fine cinders.

Details of these tests can be found at the Bureau of Buildings, New York City.

Gustav Felbeck, Jr., secretary of the H. W. Bell Co., writes CONCRETE:

Started experimenting with cinder concrete blocks, composed of fine and coarse cinders about 1907.

Test made by Prof. Ira H. Woolson at Columbia University on our cinder concrete blocks May 25, 1909.

Fire and water tests made by Columbia University for the City of New York at the Columbia Testing Station, Greenspoint, N. Y., September 30, 1912. There were two tests made on these partitions, namely one of two hours duration with two and one half minute hose stream application and one of two hours duration with five minute hose stream application. Maximum temperature 2054°.

Fire and water tests made by the Underwriters Laboratories in 1915 and 1916. Test for three hours with hose stream of five minutes. Maximum temperature, 2000°.

Approvals issued by Building Departments in all Boroughs of Greater New York, in October 1912. Blocks approved for use in the Borough of Bronx June 8, 1909.

State legislature amends Tenement House Law permitting use of hollow cement blocks manufactured by this company for the construction of vertical openings in tenement houses constructed in this city.

This is a brief synopsis of our activities in the cinder concrete block field, which we trust will be of some service to you.

Paul A. Ryan, No. 2, North McKinley Ave., Endicott, N. Y., operates a block plant where cinder concrete block are said to have been made more or less continuously under three different proprietorships since the fall of 1909 or spring of 1910. Mr. Ryan bought the plant in the spring of 1921 from Joseph H. Bohnert, who in turn is reported to have bought it from Fred Stage, 102 Odell Ave., Endicott, in the fall of 1917. Stage, according to this information, beginning in 1909 or 1910, built cellar and foundation walls of his block in the neighborhood of Broad Street and McKinley Ave.

G. Edgar Allen, investigating in Straub patent interests, advises (May 26, 1924) that the plant has been operated a much shorter time than CONCRETE's information indicates and that the original builder of the plant acknowledges the priority or validity of Straub patent claims.

It is reported to CONCRETE that the Sampson Fireproof Block Co., in charge of John R. Fallis, is making cinder block under the Cordery patent at New Rochelle with a daily production capacity of 1500 block. A very large residence was erected at New Rochelle for R. H. Cochrane, of the Universal Film Co., using cinder block (1:5 mix with some sand) by the Cordery system. This has been described and illustrated in CONCRETE.

Finch & Ostrander, 1086 Broadway, Albany, N. Y., operating under no cinder products patent (to the best of our knowledge) sent out a printed notice, early in the last winter, signed by V. L. Ostrander, as follows:

ANNOUNCEMENT

After December 15th Phone us at West 973-J for delivery of cinder concrete blocks throughout the winter.

We have a large stock of well cured blocks ready for immediate delivery. These blocks have proved their marked superiority during the short time they have been on the market. Every builder who has used them will readily testify as to their uniformly excellent

quality, their attractive appearance, their exact dimensions and their freedom from breakage.

Owing to the character of the cinder aggregate they make a dryer, warmer wall than any other, and because of the high cement content and the care used in making and curing them, they develop a higher strength than any other block on the market. They have an attractive appearance as manufactured, and also a rough surface which no other block or tile can approach for the application of stucco.

While cinder blocks are a comparatively new product in this locality, they are being sold in tremendous quantities in other cities, notably New York, Philadelphia, Chicago, Detroit, Cleveland and Trenton, where they are recognized as the modern means of securing permanent fireproof construction at low cost.

CONCRETE has a photograph (too poor for satisfactory reproduction) of 3 houses in Glens Falls, N. Y., said to have been built of cinder concrete block by J. Murray in 1912 and of a commercial garage also in Glens Falls, built of cinder block in 1916 by another builder by the name of Murray.

Two large cinder concrete brick plants are operating independent of patents (to the best of our knowledge and belief) in Philadelphia—the plants of Charles V. Walsh and Nolan Bros. Each plant has a large production capacity and has been a factor in the Philadelphia market.

The Mercer Block & Material Co., 361 Boyden Ave., Hilton, N. J., is reported to have made cinder block more than 14 years ago, and since discontinued.

J. D. Pasquale is reported to have made cinder concrete block at Vineland, N. J., for more than 20 years.

The King Partition Block Co., is reported to have a small plant for the production of cinder concrete partition tile at Long Island City, N. Y.

* * *

Francis J. Straub and the Straub Process

There seems no doubt that Francis J. Straub, of New Kensington, Pa., has done more than any other one man to bring the cinder concrete building unit to its present state of commercial availability.

Straub was a brick layer—a good one. He knows brick as bricklayers know them. He studied and experimented with cinders as an aggregate for concrete building units to make building units cheaper—from a waste product; to make them light in weight and nailable. His patent application was filed November 9, 1915, and patent at first refused. Emphasis by Straub at the Patent office of the fact that his application was an innovation in proposing to use the complete residue of the fuel after burning, finally won him his patent which was granted January 16, 1917. He made cinder block in New Kensington from about 1913 or 1914. His patent in full is as follows:

"BUILDING BLOCK AND METHOD OF MAKING THE SAME"

To all whom it may concern:

Be it known that I, FRANCIS J. STRAUB, citizen of the United States, residing at New Kensington, in the county of Westmoreland and State of Pennsylvania, have invented certain new and useful Improvements in Building-Blocks and Methods of Making the Same, of which the following is a specification.

My invention has in view to provide a building block, brick or slab composed of a mixture of lump and fine cinder, cement, and water, without the use of sand or any other material, and consists in the process of manufacturing the same and the resulting product.

Ordinarily, concrete mixtures of various kinds utilize sand, crushed stone, or other mineral as a body or filler, either wholly or partly in combination with the required proportion of cement as a binder. In carrying out my invention, I use coal cinders or ashes which are first crushed or ground to a consistency composed of pieces not larger than say three-quarters inch and retaining all of the smaller sizes and the dust and fine ashes, which are otherwise ordinarily thrown away as refuse. This crushed material, after reducing the larger lumps and clinkers, which are more or less porous, provides the coarser pieces or lumps of a maximum size sufficiently small to enable the cement to penetrate through their pores and interstices and bind the entire mass in a homogeneous body. The ground mixture also retains all of the

usual accompanying adhering portions of the cinders, in the resulting product and it is essential that the original mass of cinders and ashes as it comes from the furnace, grate bars, or other source remains in the resulting mixture without separation or change of proportions.

A suitable proportion of cement, say one-sixth, is added with the necessary water, and the batch is then very thoroughly mixed. The retained finer cinder and ashes, combined with the cement, thoroughly mixes with the larger pieces, providing a uniform quality of all sizes throughout, and measured portions of the resulting mass are molded into block-, brick-, or slab-form and then dried.

Owing to the absence of sand or other similar mineral material, the resulting blocks, etc., harden by natural evaporation and at the same time retain the porous light qualities of the original cinders to a very considerable degree, while at the same time having the necessary strength and resistance to crushing strains. The presence of the larger lumps regularly mixed throughout the mass maintain sufficient porosity to insure avoidance of moisture, while the light consistence of the entire body and the avoidance of great density and accompanying resistance by elimination of sand or the like, leaves the block in a condition of penetrability or cleavage by any sharp instrument. It can therefore be driven into by a nail, or easily cut, without impairing its strength or homogeneity, so that it may be easily used for attachment of wooden trim, etc., without the necessity of supplemental nailing strips or the like. The surface, being rough and uneven, is likewise of great holding affinity for plaster or other like coating material, so that the blocks are well adapted to building purposes. They are fireproof, moisture proof and sound proof, and, due to the low cost of the raw material and labor, are extremely cheap.

What I claim is:

1. The herein described process of making building blocks and the like consisting in crushing or grinding an original mass of coal cinder and ashes without separation, mixing the entire mass of coarse and fine material with a suitable proportion of cement and water, and molding and drying the same in block form.

2. A building block composed of a mixture of coarse and fine coal cinder and ashes, retaining all of the original mass, cement, and water.

3. A building block consisting of a mixture of coal cinders and ashes taken in its original composition as products of combustion and crushed to a consistency ranging from dust to lumps of about three quarter inch in size and retaining all of the original mass in its natural resulting combination, and then mixed with a suitable proportion of cement and water and molded in block form, substantially as set forth.

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

There has been at least one court decision on this patent in Straub's favor. This serves to emphasize the features of the Straub patent upon which he bases his effort at monopoly of cinder building unit production.

Suit was brought by Straub against H. P. Campbell and Jacob Miller and a decision handed down by Judge C. J. Buffington, in the United States Circuit Court of Appeals for the third district, reversing the decree of the District Court of the United States for the Western District of Pennsylvania and upholding the Straub patent as having been infringed. Campbell had operated a gravel concrete block plant close by Straub's cinder block plant. He began making a competing cinder block in which it appears it was the plan to evade the Straub patent by putting some sand in the mix with the cinders.

Straub's patent, following after other patents covering the use of cinders in concrete building units, stressed the use of *whole cinders*—that being the term which Straub himself not infrequently uses. The patent describes a "process of making building block and the like" by "crushing or grinding *an original mass of coal cinders and ashes without separation.*"

This is quoted (the italics our own) from the patent summary containing three claims. The body of the patent mentions the porous nature of the block, its lightness and nailability.

The court decision (July 3, 1919) mentions advantages of Straub block as providing walls which are "sound proof, damp proof, fireproof and are electrically non-conductors," but more specifically:

The gist of his invention, for such we think it is, was in taking ordinary furnace ashes and using the whole of that product without sifting or selection. He found that by taking the whole of the ashes—clinkers, fine dust and all—and grinding the entire product and mixing it with cement and water, he was able to produce a new and useful article in the building art.

Again the decision says:

While the use of cinders in groutings, in foundations, in walks, roads and other structures, was old, and while even screened ashes had been used in building blocks, no one before Straub conceived the novel idea of taking the whole ash product—clinkers and ash alike, half burned and wholly burned, lumps and dust—in fact, the entire run of the grate, and using the whole waste product in its raw state, rolling or grinding the whole mass.

In special reference to Straub's competitor the decision says:

Before Straub's block came on the market, Campbell had made blocks of sand and cement. He changed from that process and copied Straub's by making a block which used the entire ash body, the cinders and ash being crushed together on rolls of Straub's design. It is said he does not infringe because he uses sand. Now, while it is clear that Straub uses no sand and that his patent said none was to be used, and that sand is not an element of the claim quoted above, the weight of the proof shows us that Campbell uses the small amount of sand he does, not to make a building block that a nail cannot be driven into; not to make his block unlike Straub's, or to forego and avoid what Straub showed in his patent, but to really get the real thing Straub gave the building art, and escape paying tribute for such use by using a small and negligible quantity of sand. Campbell's infringing block does not make the block nail-proof, as the sand and cement blocks he was previously manufacturing were, but one can drive nails into the infringing block and the block holds the nails just as Straub first showed could be done.

Thus in the court's view the nailability of the infringing block appears to have fixed the guilt definitely on the infringer.

Nailability as a characteristic of concrete is not of course confined to Straub's kind of concrete. Nailability was a feature of Grosvenor Atterbury's work on which a patent was given in 1915 and Nailcode (another patent) was a well known proprietary mix on the market for years. Sawdust and asbestos are both commonly used for a nailing mix. The Staple concrete fence post which had a nailing mix on one side to receive staples, is another example.

With his court decision greatly strengthening his position, Straub energetically set about licensing plants. He is the first, it appears, who, visioning the possibilities of cinder concrete units, went about it to establish plants on a broad national scale.

Straub has the convincing appeal of a plain man—a brick layer. Almost everybody who knows Straub likes him and believes him sincere. He had a successful plant at New Kensington, where he began making cinder block about 1913. This was his laboratory. He ran fire tests, and had them made under expert supervision. He developed his own crushing rolls for reducing the cinders. There was a real problem in this because cinders mat on the rolls and cause more excessive wear than some much harder materials. He arranged with the Underwriters Laboratories for fire tests. These were highly successful and "Straub blox" were given a $2\frac{1}{2}$ hour rating.¹ This rating applies not necessarily to all block made under the Straub patent. The Straub patent does not comprehend an exact process. Each plant has its own problems of material, machinery and labor. When samples of Straub block disclose upon examination by the Underwriters Laboratories those qualities which indicate (without additional fire tests) a degree of fire resistance equal to those Straub blocks which were used in the original official tests, then the $2\frac{1}{2}$ hour Underwriters Laboratories rating applies.

In the meantime the Brooklyn Crozite Brick Co., which had a large and elaborately equipped plant for making concrete brick on Crozier machines,² became interested in the use of cinders and appealed to its attorneys as to the status of the Straub patent. The Crozite company was advised in effect: "before you use cinder aggregate see Straub."

This led very shortly to a consolidation of interests and a new company, Crozier-Straub Inc., 120 West 42nd St., New York City, which took over the Straub patents. This was early in 1922 and at that time there were about 20 Straub licensees. This number has been increased by energetic selling and by the phenomenal success of the cinder block until there are now about 50 Straub plants with a capacity production (1923) of about 40 million blocks.

The Straub licensees have formed an association, the National Cinder Concrete Products Association, F. J. Straub president, for cooperative research and promotion and undoubtedly for mutual protection.

Straub spends a great deal of his time in the field, interesting new local capital here and there, and on call from present licensees to help them solve their plant problems.

Cinder products manufacture is like most other enterprises; it has its problems and the licensing organization is making an effort to see that quality is maintained. This of course has not been 100% successful. The aim is a product having a compressive strength of at least 750 lbs. to the square inch, gross area.

What part of the license cost and what part of the royalties paid to Crozier-Straub Inc., are used to raise and maintain the standards demanded in license agreements the writer does not know. These agreements, it is understood, are so drawn that licenses may be forfeited unless quality is maintained to the stated standard. Recently a representative of Crozier-Straub said that plans are now under way to insist upon the maintenance of quality.

Cinders are not by any means a ready-made cure-all as an aggregate. Cinders are not all alike any more than all coal is of the same quality or all steam plants of equal efficiency. Some Straub plants use bituminous cinders; some use anthracite cinders. The best looking Straub blocks the writer has seen were made of anthracite cinders. Looks, however, are not in all cases a safe basis of judgment. Mr. Straub says hard coal cinders demand finer crushing than bituminous cinders for equal results. Mr. Straub is keenly alive to the need for constant quality supervision.

Cinders are a harsh working aggregate. They are probably less easily compacted in a mold box than gravel. In the operation of a Straub cinder block plant it is common to dump the cinders into the boot of an elevator emptying to a crusher, the product of the crusher going to bins and thence to the mixer. In operation most of the Straub plants have one feature differing from most other block plant operations. The mix is conveyed to the floor near the molding machine in carts or barrows. Multiplex, toggle pressure, hand operated machines have been extensively used. Crews work usually on a wage plan of fixed output plus bonus for excess production, or straight piece work. As the block are carried from the machine they are stacked and the machine is gradually moved away from the pile. A simple rack system is used with loose boards and wood block separators between tiers to space the tiers a little more than block height.

Some Straub plants are now changing equipment, to some extent experimenting to get big production and thorough compacting and employing stationary equipment. Anchor stripper machines with automatic tampers, Hobbs machines for 12-in. block, Post Punch equipment and other machines are being employed. The rebuilt plant of the Brooklyn Crozite Brick Co. is a kind of laboratory for the Straub parent organization. Mr. Straub has developed a pressed steel pallet which is being used with satisfaction.

Henry Boetcher, an architect, of the Armstrong Cork Co., is extensively interested in Straub block.

¹See CONCRETE for Oct. 1922, p. 123.

²See CONCRETE, Feb. 1921, p. 74.

Mr. Boetcher is president of the Lancaster Concrete Tile Co., Lancaster, Pa., a very successful Straub licensee, and also actively interested in the Philadelphia Partition & Building Block Co., a Straub licensee in the Philadelphia territory. This company has installed a specially built machine of the automatic pressure type, entirely new in the concrete products field, although in some respects resembling the Jaeger-Kenny hydraulic press.

Philadelphia, where stone masonry is traditional, has provided a very active territory in the promotion of the cinder concrete building unit. The Penn Building Block Co., Harold Weeks, president, built a plant to make cinder concrete products in 1923, where a Straub licensee was already in control (under the Straub patent) of the local territory. The Penn company finally came under the Straub patent as a sub-licensee under the Philadelphia Partition & Building Block Co. Recently the Penn company has come in under the Bo process patents and the present patent relationship and status there are, at this writing, problematical.

The Detroit Cinder Block & Tile Co., Straub licensee, started under excellent auspices in the fall of 1923³ and now has an output of about 6000 block per day, insufficient to meet demands. Block being made recently are reported by Manager Jones as testing above 800 lbs.

The progress of Straub block is indicated plainly in letters written by local manufacturers, architects and users generally. The following are typical of many and are eloquent of Straub success:-

To F. J. STRAUB FROM JOHN MCCARTNEY KENNEDY, ATTORNEY, PITTSBURGH, FEB. 12, 1918

In the Fall of 1916 you furnished the cinder blocks necessary for the construction of a ware house * * * 30 ft. wide, 385 ft. long and about 12 ft. high. The walls of this building were constructed of solid cinder block 4 x 8 x 12 in. with pilasters of 8 x 8 x 16 hollow cinder block set on 16 ft. centers. This building has been entirely satisfactory and after the filling which was necessary in the foundation had dried there seemed to be no evidence of dampness penetrating the walls.

To E. B. CADWELL & Co., Inc., FROM HENRY BOETCHER, PRESIDENT, LANCASTER CONCRETE TILE CO., LANCASTER, PA., OCT. 16, 1922

The following is the history of our company from the time we started to manufacture Straub Patented Cinder Concrete Blocks on August 17th, 1920. On this day we manufactured 395—8x8x16 size blocks. On the following day, August 18th, we manufactured 437—4x8x16 size blocks. We gradually increased our production and for the month of September 1920 manufactured 13,084, 8x8x16 blocks, 10,922 4x8x16 blocks, making a total of 24,006 blocks manufactured for September 1920. From this amount our production has increased until for the past month of September 1922, we manufactured 93,923 blocks of all sizes. This production of 93,923 blocks for the month of September represents a production of 4,025 blocks of the 8x8x16 size per working day. When we started manufacturing the Straub blocks there was practically no demand for any kind of building material in this section, the depression following the war still being in effect during the year of 1921. As the building business picked up a bit, we received our share of the increased business, and have been ever since.

During July 1922, we put an addition on our factory, increasing the floor space 100%, and we are trying to increase the demand for blocks so that another addition will soon be necessary.

We have been well satisfied with the profit obtained from operating our plant. During the first year owing to the depression, we did not get very good results, but since business picked up, the returns were all we could expect. Net profits from March 1st, to September 30th, 1922 were as follows: Month of March, \$1,751.20; April, \$3,231.73; May, \$3,480.54; June, \$4,094.31; July, \$3,248.48; August, \$4,469.65; and September, \$3,536.68; making a total gain of \$23,812.59 for a period of seven months. This \$23,812.59 net gain, represents an income on a capital stock of \$80,500. The remaining months of this year, October, November and December have every indication of being as good or better than the previous seven months.

We find that Straub cinder concrete blocks are increasing in popularity wherever introduced for any length of time. In some localities where we introduced them we did not have much difficulty convincing the architects, contractors, and general public as to their many good

qualities and advantages over the ordinary building materials, but in some localities it was a hard fight to get any one to use them. In the City of Lancaster when we first started manufacturing these blocks, it was difficult to convince anyone that they were satisfactory for foundations, but after two years of perseverance we are glad to say that a great number of buildings are using them for cellar walls and that they are giving satisfaction in every instance. They have been found to make a very dry cellar wall of clean appearance which is quite an advantage over any other material that can be used for cellar walls. Above the ground they are specified by all the leading architects for stuccoed walls and for a backing for 4-in. of brick veneer. In both methods of construction, furring and lathing are not specified where Straub cinder blocks are used, but the plaster is applied directly to the block, as it is now generally recognized to be absolutely damp-proof. The fact that nails can be driven into Straub blocks the same as into wood, is considered a great advantage by the contractor. Their insulating qualities make them especially desirable for most any type of building. As they are fireproof they have all the advantages of other fireproof materials at a much lower cost.

We believe the above will give you a pretty good idea of what we think of the Straub blocks from a manufacturers' and builders' standpoint.

P. S. The Capital Stock of the Lancaster Concrete Tile Company on January 1st, 1922 was \$73,500.00, this includes \$10,600.00 of stock used to pay for licenses covering additional territory. Prior to October 1st, 1922 the capital stock had been increased out of net profits to \$80,500.00 to enable the enlargement of the plant, to take care of increasing business.

To W. H. BLACKWOOD, MANAGER, HUDSON FIREPROOF BLOCK CO., HOMESTEAD, NORTH BERGEN, N. J., FROM BENJAMIN HOWELL LACKEY, JOSEPH NORMAN HETTEL, ARCHITECTS, 5 HUDSON ST., CAMDEN, N. J., JULY 23, 1923

* * * We are specifying Straub Patent Cinder Concrete Block on practically all our work.

We, like all others, were somewhat skeptical in the beginning as to their value and adaptability. It was fully six months between Mr. Goodwin's first visit to our office and the time when we used the first blocks. Since then, however, we have become thoroughly converted and, as I have said before, are using them in some form or other on practically every job.

We have two school buildings under construction, at the present time, for the Borough of Haddonfield, N. J., in which we are using cinder block. One of these buildings is one story and basement. On this building we are using 8 x 12 x 16 blocks, which will be stuccoed on the exterior and plastered directly on the blocks on the interior. The other school is two stories and basement in height. For the basement walls we used 12 in. cinder concrete blocks with a 4 in. brick veneer and in the first and second stories 8 in. cinder blocks with 4 in brick veneer. This building will also be plastered directly on the cinder blocks on the inside.

This effects a very decided saving, as the labor and materials necessary for stripping and lathing is saved; also, the cinder blocks are cheaper than bricks and can be laid up much more quickly, making another decided saving in labor and material.

We are about to commence construction of a large school building for the City of Camden, in which we are using 12 in. curtain walls made up of 4 in. brick veneer with 8 in. cinder concrete block backing. This is a three story and basement building with structural steel frame work.

When the brick veneer is used for the cinder concrete blocks the brick should be bonded into the block by carrying a course of brick into the inside of the wall every two blocks in height.

In addition to this school work we have under construction a bank building, a store and apartment building and a small office building, in all of which we are using cinder concrete block.

We have completed several garage buildings, store buildings and apartment buildings, in all of which these same blocks were used and in all of which they have given perfect satisfaction.

The Mr. Goodwin mentioned in the above letter is secretary and treasurer of the Concrete Specialties Co., Camden, N. J., a very successful Straub licensee who has extended his business to a considerable shipping distance outside Camden. This company piled up a tremendous stock of block by continuous winter operation.⁴

QUOTATIONS FROM A FOUR PAGE REPORT BY JOHN A. FERGUSON, CONSULTING ENGINEER, PITTSBURGH, PA., ON STRAUB CINDER CONCRETE BUILDING BLOCKS

In the foundations and cellar walls of dwelling houses, the blocks were eight inches in thickness and in almost all cases were not water-proofed on the outside. The same was true of the foundation walls of the store buildings visited. In all cases the walls were absolutely dry, although there were places where the ground outside the walls was wet to saturation and muddy and soft on the surface.

³See CONCRETE, Oct. 1923, p. 137.

⁴See CONCRETE, May, 1924, p. 195.

Although it had rained all night and had rained all day, a dashing heavy rain, the inside faces of the four inch cinder concrete block walls were in all cases perfectly dry, except in one instance where the water stood on the ground outside of the wall several inches deep. However it is not felt that the blocks were intended to resist water pressures.

* * *

I saw a small garage building built out of these blocks which had been subjected to a fire test. The temperature of the test ranged from 1000° to 1700° Fahrenheit for a period of one hour and fifteen minutes. The temperature in the hollow spaces of the cinder concrete blocks did not exceed 200°, and on the outside of the block, protected from radiation of the air 100° was the maximum attained.

* * *

The fire-resistive characteristics of cinder concrete together with its insulating qualities have long been recognized.

To F. J. STRAUB, FROM APOLLO STEEL CO., APOLLO, PENN., JULY 30, 1921.

We thought it might interest you to have a picture of our new housing development at Apollo.⁵

We built sixteen houses, the outside walls and chimneys are built of cinder blocks, our own make, and we noted during the fall and winter—1920-21 how dry they were on the inside.

The cinder blocks are in our opinion the most economical building material for permanent building today.

To F. J. STRAUB, FROM RICHARD NEFF, CHIEF ENGINEER, DEPARTMENT OF PUBLIC SAFETY, BUREAU OF BUILDING INSPECTION, CITY OF PITTSBURGH, JAN. 17, 1922

In accordance with your request, the writer made a trip to New Kensington, Pa., December 4th, 1921, to ascertain the value and various conditions in the manufacture and use of the Straub Cinder Concrete Block, and I take this opportunity to report to you my findings and general opinion of the conditions which I found on this occasion.

In the first place I was astounded at the fact that the whole town of New Kensington seemed to be built of cinder concrete block for no matter where I looked the cinder block was used almost exclusively.

I took this trip with the thought in mind that my opinion could not be favorable to the cinder block, but I must admit that I came away with a wholly different view on the subject. I have come to the conclusion that cinder blocks, if made right, are an asset to the building world and should be more extensively used. I would further state that the thing that stands out foremost in favor of the block is the Fire Test, which was conducted at New Kensington. I observed there the action of what was probably as severe a test as could be made of any material, a very hot fire and then while the blocks were still red-hot the water applied showed no perceptible effect on the blocks. The surface of the blocks was hard and firm with no disintegration whatsoever. The penetration of fire seemed to be less than a quarter of an inch. It seems to me from a fire-proof standpoint the cinder block stands out paramount from any other known building material of today.

During my inspection of many of the fifteen hundred, or more, homes, buildings, garages and manufacturing plants in this town, I found several things worth noting and cannot refrain from making mention of them. I found the various buildings I inspected to be perfectly dry and I noted particularly the foundations which were totally under ground and not having plastered walls.

Another very interesting feature was the Bottling Works building which was destroyed by fire. Although the walls fell the cinder blocks were found to be intact and were being used again in rebuilding.

The fact that nails can be driven into the block for the purpose of attaching wood or other materials used in the course of construction, without causing cracks or splits in the blocks also developing a good clinch on the nails equal to that of wood is a point to be considered.

In examining some of the blocks that had been placed in the weather about seven years ago, I found that part of the nail which was driven into the block to be in perfect condition and the part exposed almost destroyed. This to my mind proves the cinder block to be damp proof.

The four inch blocks make excellent back-up blocks and should serve to keep the structure dry as well as warm. The many buildings I saw of four inch exterior walls were remarkable but as an engineer I would not recommend walls of this thickness.

The bond developed between the cinder block and the mortar joint is very strong and therefore makes a strong and permanent wall.

Another noteworthy feature was the sidewalk laid of the large 8x4x24 in. back-up blocks. This walk was laid about seven years ago directly on the ground. The blocks were not broken, disintegrated or worn, thereby proving that the weather or wear had no effect on the block.

The various things I have mentioned are but a few that could be said in favor of the Straub cinder block and since visiting your town I am convinced that the block made according to your process of manufacture is an innovation in the concrete block industry. Of

course your process and method must be adhered to, to maintain the efficiency of the cinder block.

In conclusion allow me to say that I believe that the cinder block could be used for all classes of buildings where concrete blocks are used and I fully recommend the block for durability, safety and economy.

* * *

Sigurd Bo and the Bo Process

Sigurd Bo is also a bricklayer. As a boy in Norway, one of a large family, he went to cinder piles to pick out the unburned fuel. Abroad he saw cinders used as an aggregate in concrete products. He came to America 20 years ago and laid brick on many large jobs. In New York City he saw big trucks loaded with cinders—a waste product expensive to dispose of—dump their contents into scows at the waterfront. A tug took a string of these scows out to deep water and dumped them on sea bottom. The tugs were paid in proportion to the loaded scows they could take out and bring back. It was said some did not get beyond the harbor on dark nights. The United States Government pays out huge sums to keep the ship channels dredged to a proper depth. Bo went as a hand on one of the big sand suckers and saw great quantities of cinders come up off the harbor bottom. Truck, scow and tug owners paid for dumping the cinders; Uncle Sam paying again to take them out of the way of ships. This Mr. Bo relates as the basis of his inspiration.

In Albany about eight years ago Bo was laying brick in the day time and at night working with cinder concrete—making block, brick and beams. These were tested in the laboratory of a nearby college. Bo believed in the utilization of cinders in two ways—saving the unburned fuel which as a boy he had picked out of the dumps in Norway and making the cinders proper into a fireproof building material.

The Bo Process on which patent was applied for May 11, 1921, and granted Aug. 28, 1923, is the result. The Bo idea appears directly opposed to the Straub idea in an important fundamental of procedure. Straub uses everything in the cinders "without separation." Mr. Bo says he believes that good concrete can be made out of some cinders and not out of other cinders. He finds that cinders contain various percentages, 5 to 50, of unburned fuel and proposes to recover that material for two reasons, first, for the value of the fuel and second to improve the aggregate. As a part of the process other impurities are to be removed and by a special though inexpensive bath, the absorption of the cinders controlled.

Sigurd Bo says he has no quarrel with Francis J. Straub. He believes the public will be better served by maintaining more nearly standardized building units if the cinder products business is controlled by a few rather than being thrown wide-open to anybody who has access to a cinder pile. He points to back-lot operations in the general products field as a situation to be avoided in the cinder field if cinder concrete building units are to be of the greatest public benefit.

SEVENTEEN POINTS OF THE BO PATENT

1. A plastic body comprising a binder and crushed coal ashes substantially free from coke and soluble salts.
2. A plastic body comprising crushed clinkers of coal ashes and fine coal ashes and being substantially free from coke and soluble salts.
3. A plastic body comprising cement and crushed coal ashes with the coke substantially removed, and the water absorptive properties reduced.
4. The process of making plastic bodies which consists in separating the fine particles from coal ashes, subjecting the residue to a bath to separate the coke and reduce the water absorptive properties of the remainder, crushing the latter while moist, combining the crushed

(Continued on page 251)

⁵See CONCRETE, Feb., 1922, p. 89.

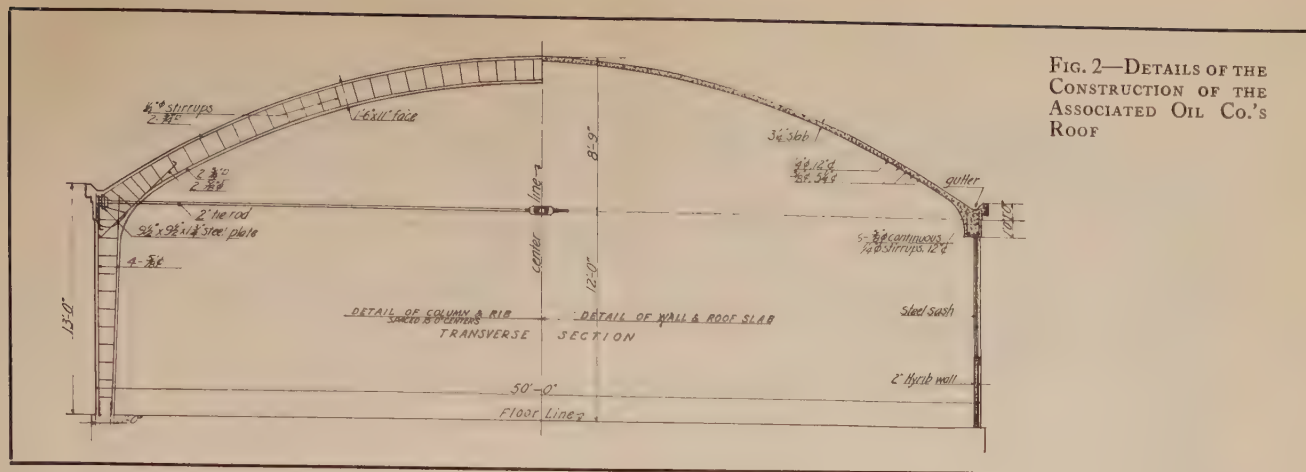


FIG. 2—DETAILS OF THE CONSTRUCTION OF THE ASSOCIATED OIL CO.'S ROOF

Long Span Concrete Construction

By A. B. VILLADSEN
SALT LAKE CITY, UTAH

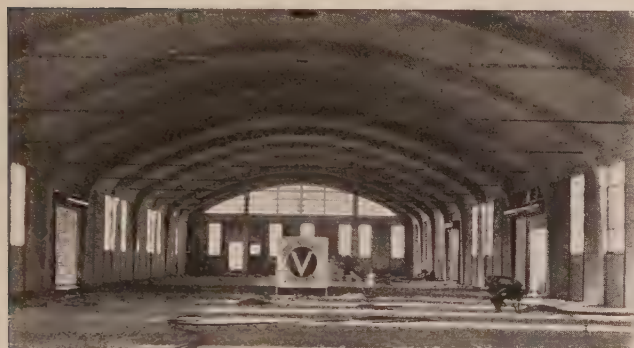


FIG. 1—WAREHOUSE FOR ASSOCIATED OIL CO. AT AVON, CALIF., WITH BOWSTRING ARCH ROOF. THE ONLY MAINTENANCE CHARGE ON A ROOF OF THIS KIND IS THE OCCASIONAL PAINTING OF THE TIE-RODS



FIG. 3—WAGON SHED FOR CLOVER LEAF DAIRY, SALT LAKE CITY, UTAH

on account of any local conditions, but because a close study of the advantages and cost led to the conclusion that a roof of this type might be considered, as a general rule, to be the most effective roof on a plain rectangular area.

The same type is coming into common use in Europe for warehouses, stores, auditoriums, machine shops, train sheds, public markets, and a similar form of arch is now well known for highway bridges.

It is apparent that the great advantage of the arch over a plain long span concrete girder is in lightness and economy of material. A plain girder to resist the same loading would be designed for a bending moment of $\frac{1}{8}WL^2$ figured on both dead and live loads.



FIG. 4—GARAGE, 50-FT. SPAN WITH RIGID FRAME

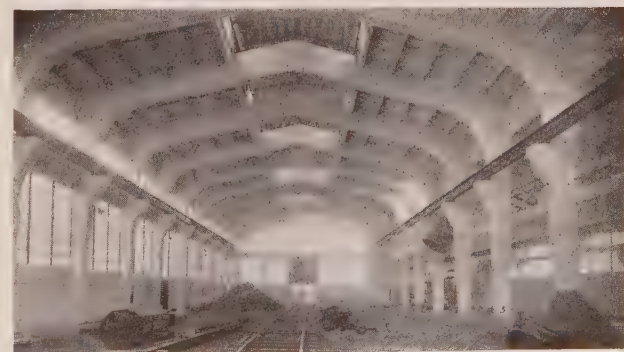
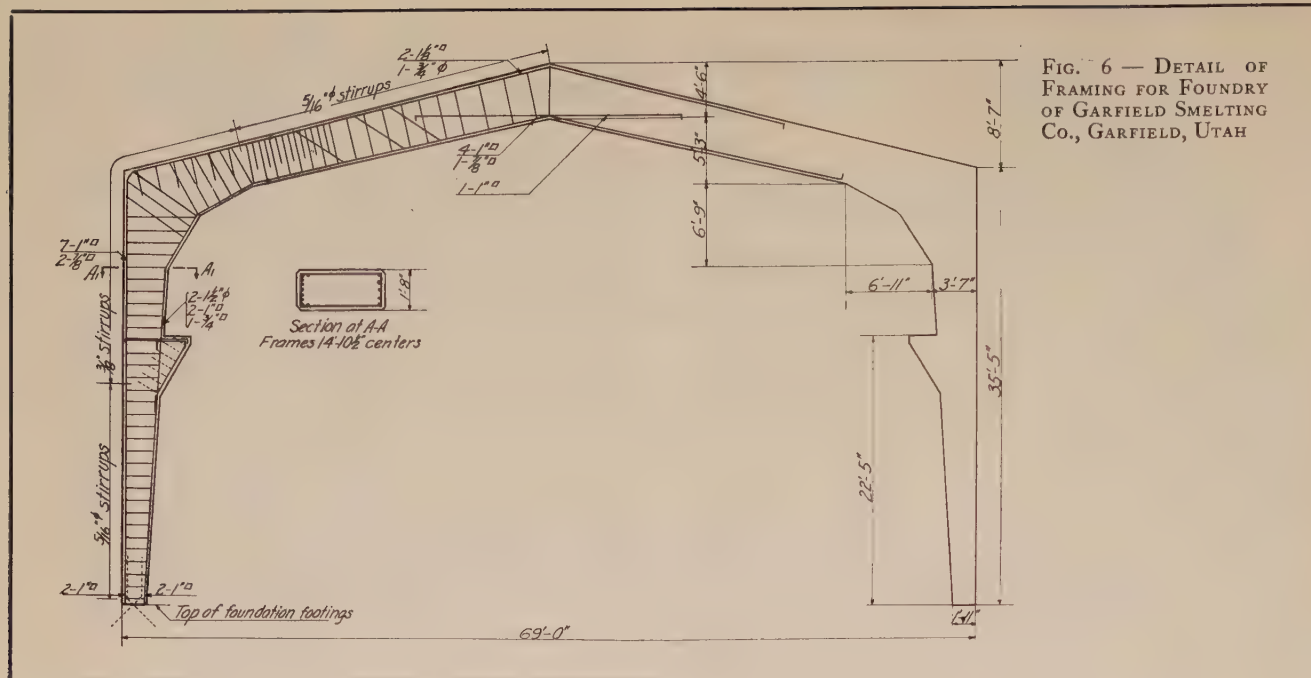


FIG. 5—FOUNDRY GARFIELD SMELTER, AMERICAN SMELTING & REFINING CO., UTAH. SPAN 70 FT. BUILDING 200 FT. LONG AND 45 FT. HIGH

In selecting the type of construction for a long span in a building, the designer finds that concrete, as he is accustomed to use it on short spans, presents several difficulties, which frequently lead him to dispense with the advantages of concrete construction on this part of the building, and use other materials. The ordinary concrete girder takes up considerable head-room and uses a large amount of material, which is not only expensive in itself, but also adds to the expense of columns and foundations. The obstruction of light may be another disadvantage.

Some examples are given below of long spans which have been designed to avoid the shortcomings of the plain girders.

Fig. 1 shows a warehouse built in 1923 for the Associated Oil Co., at Avon, near San Francisco, Calif. This particular form of arched roof was not selected



In the arched ribs, all moments are relatively small. The arches are formed to follow the parabolic curves, and will therefore take the dead load, representing the weight of the concrete itself without introducing any bending moment, but only a small uniform compression. It is not even necessary that the ribs should carry the whole dead weight of the concrete roof slab, which follows the same curve and partly supports itself by arch action. The severe stress comes from a live load on one-half the area. The maximum moment for this loading will occur at the quarter points, being positive on one side of the span and negative on the other side.

The bents are spaced 15 ft. centers, and it is necessary to reinforce the roof slab to carry its live load to the ribs, but when advantage is taken of the continuity of the slabs, and also of the fact that they carry their own dead weight by arch action, it is only necessary to use a 3 1/2-in. slab.

The resultant saving in weight for the whole roof may be gauged by a computation of the roof shown in Fig. 2, which weighs 4000 tons. To cover the same area with concrete girders and 4-in. slab would require a weight of 8600 tons.

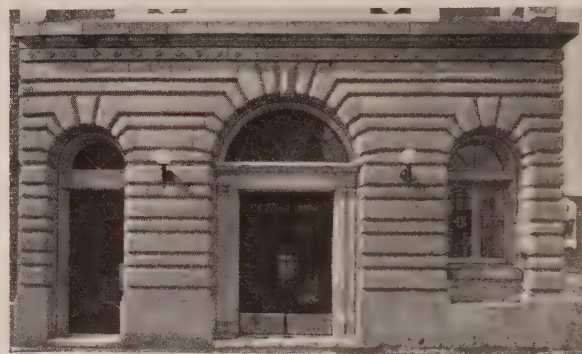
Fig. 3 shows a similar roof, using wood sheathing, constructed in 1922 for the Clover Leaf Dairy in Salt Lake City, Utah.

These concrete frame buildings compare favorably in cost with non-fireproofed structural steel frames.

Figs. 4 and 5 show rigid frame structures. The former is a garage, and the latter (Fig. 5), the one with the crane beam, is a foundry at the Garfield Smelter.

The rigid frame is another effective method of approaching the long-span problem. It is particularly well adapted for a building of the type of the Garfield foundry. The solution of stresses in rigid frames is based on calculations which are somewhat involved, but which have been very much simplified in recent years by the use of sets of curves giving the required factors. Some very applicable data of this nature have been published by Sanford Thompson and Smulski in *Cement Era* of March, 1913, also by Hool and Johnson in their *Handbook for Concrete Engineers*, and by Mikishi Abe in *Bulletin 107*, University of Illinois.

Bank Front Rebuilt With Concrete Stone



NEW BANK FRONT ABOVE—AS THE BUILDING DID LOOK, BELOW

This is the Peoples State Bank of Lansing, Mich., before and after the construction of a new front of concrete stone made by the United Stone Co., Lansing. S. D. Butterworth is the architect, and the construction was done by the Reniger Construction Co.

Curing Conditions of Concrete Drain Tile

A Factor of Resistance to Sulfate Waters

BY DALTON G. MILLER
SENIOR DRAINAGE ENGINEER
U. S. DEPARTMENT OF AGRICULTURE

Paper before Minnesota Surveyors' and Engineers' Society, Minneapolis, Minnesota, Feb. 22, 1924. This report is based on experiments at the draitile laboratory, University Farm, St. Paul, Minnesota, conducted by the Department of Agriculture of the University of Minnesota, the Department of Drainage and Waters of the State of Minnesota and the U. S. Department of Agriculture. These experiments are designed principally to aid in the general improvement of the quality of farm draitile and particularly to develop tile that will endure under all soil conditions.

Much has been written relative to increasing the resistance of concrete to sulfate waters by improving the quality. Generally, great emphasis is placed on all the details of concrete making, ending with the statement that "the concrete should be well cured." So far as known, little effort has been made to define what constituted "well cured concrete" as a factor in developing resistance.

In the cooperative drain tile laboratory at University Farm, it soon became evident that the life of specimens in solutions of magnesium sulfate ($MgSO_4$) or sodium sulfate (Na_2SO_4) was greatly influenced by curing conditions, and that undue variations in this alone were sufficient to outweigh all other factors. The data upon which the conclusions of this paper are based are not complete, and represent but a small part of the work that is being done along this line, but it is believed are complete enough at this time to show the latent possibilities of raising the resistance of concrete to sulfate waters by proper curing.

For those not in touch with the work that has been carried on at University Farm for the past three years, a brief summary will be given of such phases as will make possible a clear understanding of the figures presented in this paper.

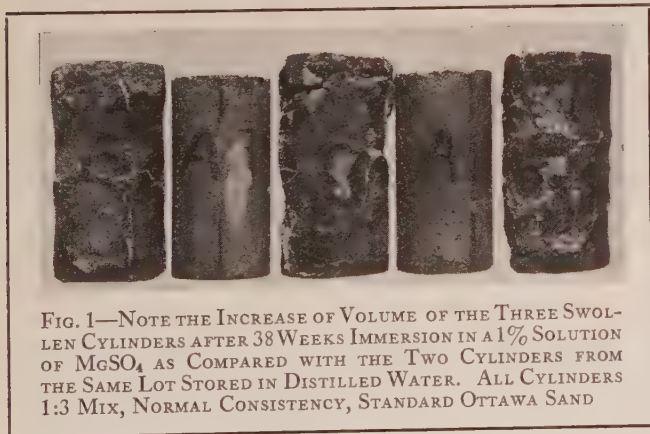


FIG. 1—NOTE THE INCREASE OF VOLUME OF THE THREE SWOLLEN CYLINDERS AFTER 38 WEEKS IMMERSION IN A 1% SOLUTION OF $MgSO_4$ AS COMPARED WITH THE TWO CYLINDERS FROM THE SAME LOT STORED IN DISTILLED WATER. ALL CYLINDERS 1:3 MIX, NORMAL CONSISTENCY, STANDARD OTTAWA SAND

The so-called "alkali" problem in Minnesota was early resolved into sulfates of magnesium and sodium, and as the action on concrete of each of these is accompanied by a definite increase of volume (see Fig. 1), it was decided to use both the actual increase and the rate of increase, as indicated by length changes, as a basis for comparing the behavior

of different specimens in the same solution, as well as the effect of different solutions on similar specimens.

It is the practice in the laboratory to store experimental pieces in solutions in earthenware jars, the solutions being changed weekly, as it was found that systematic changing was necessary for consistent results. 2-in. by 4-in. cylinders have been used, as this size reduced to the minimum the volume of concrete in all jars. Moreover, the 2-in. diameter, in a general way, approximates the thickness of the wall of the average tile used in public ditch work in Minnesota.

The cylinders are made in batches of 9, each series consisting of 5 batches made on different days. In each end of three cylinders of each batch, a 1-in. round-head brass screw is set in neat cement. The ends of the remaining 6 cylinders in each batch are left smooth, these being used for compression tests.

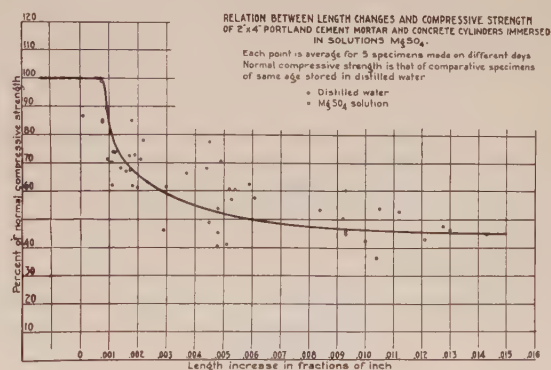


FIG. 2

The number of cylinders stored in each jar has been 10, 15, or 20, in the majority of cases the number being 15. The laboratory standard specimen is mixed 1:3 by volume, normal consistency, with the aggregate graded to produce a fineness modulus of 4.67, the largest pebbles passing a $\frac{3}{8}$ -in. screen.

The results of some of the earlier work are shown by the curves in Figs. 2, 3, and 4. Fig. 2 is based on tests of some 400 cylinders, and indicates that any appreciable length increase is accompanied by loss of strength, as those cylinders stored in distilled water generally show no tendency to expand, but, on the contrary, in many cases slightly contract. The points from which this curve was developed represent length changes of cylinders, with screws and compression tests of blank end cylinders from the same batches; consequently, as the cylinders tested under compression are not the ones actually measured, the indicated relation between change of volume and strength ratio based on these tests is not quite exact. Also, the ends of many of the cylinders in the solutions become quite soft and

crumble badly at the edges, rendering compression results of such cylinders more erratic than usual, even after capping with plaster of paris. Study of this curve indicates that an increase in length of .010 in. in a 4-in. specimen means the loss of strength is perhaps not far from 50%.

One per cent solutions are used as a standard, as it has been found that the destructive effect of a 4% solution of $MgSO_4$ on portland cement concrete is not much greater than that of a 1% solution, although below 1% the action is closely proportional to the

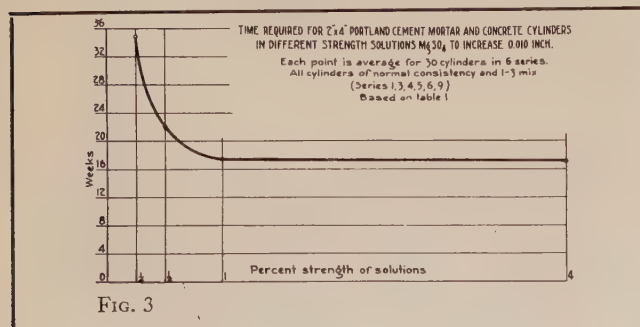


FIG. 3

solution strength. This is illustrated by Figs. 3 and 4, based on Tables 1 and 2, showing changes of volume and compressive strength ratios respectively. It will be noted that the two curves are of the same general type.

STRENGTH AND CURING CONDITION OF CONCRETE AND RESISTANCE TO SULFATE WATERS

It is usually held that the quality of concrete for all ordinary purposes is fairly indicated by test results under compression. It has been found by experiments

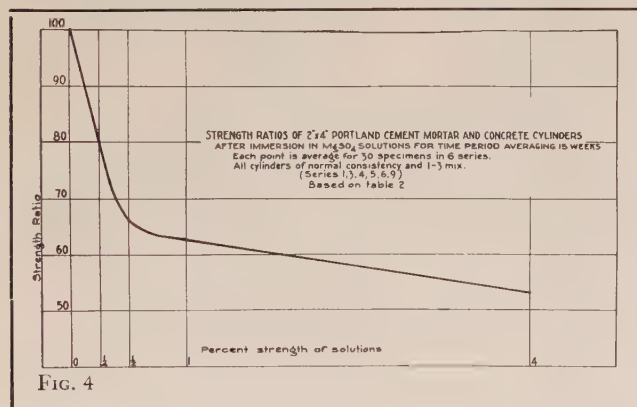


FIG. 4

in the drain tile laboratory that strength is a reasonably good indicator of resistance to sulfate waters, as generally the strongest concrete is the most resistant. Consequently, as would be expected, variations in the mix, consistency, and grading of the aggregate which tend to increase the compressive strength also tend to prolong the life of the specimens. Because of this, it is perhaps all the more significant that variations in the curing conditions may bring about great or little resistance, independent of the influence of such variations on the strength of the concrete. This is illustrated by the curves in Fig. 5, which show results obtained by varying the conditions of the 21-day curing period of standard Ottawa sand cylinders. As will be noted, the cylinders cured longest in water attained the highest strength at 28 days, but showed the least resistance to the action of a 1% solution of sodium sulfate, resistance having been closely proportional to the length of time the cylinders were stored in air, the desirable time limit of which evidently was not reached in any of

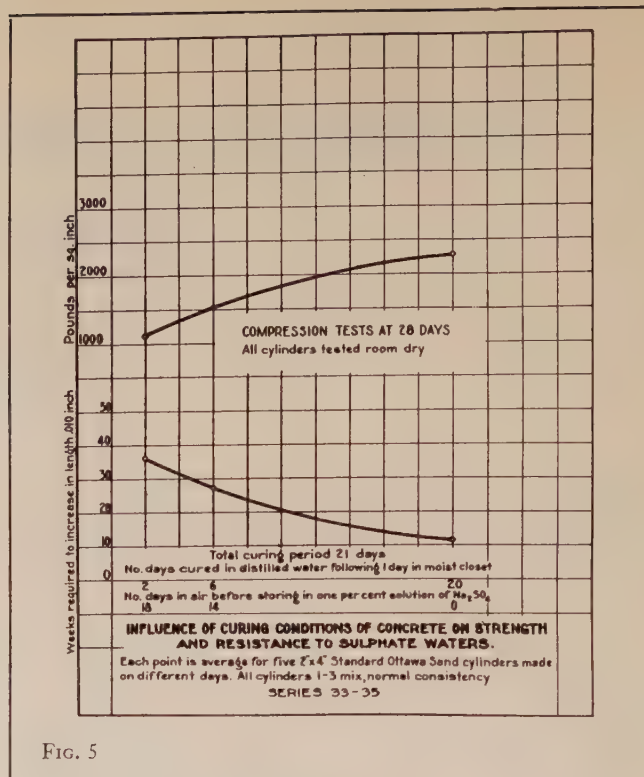


FIG. 5

these cases. This does not mean that the cylinders cured 20 days in water would not have been both stronger and more resistant to disintegration than those cured either 2 or 6 days in water had the storage conditions in air been the same. It does, however, emphasize the fact that there is much more to the curing of concrete in its relation to the sulfate problem than is generally realized. Other similar tests under way with the laboratory standard concrete cylinders in both $MgSO_4$ and Na_2SO_4 solutions clearly indicate, that although the life in each case will be longer, failure of the specimens will be in the same order as the cylinders of Fig. 5.

Experiments in the laboratory to show the influence of long-time water curing in developing resistance to sulfates, although not completed, indicate that even when the concrete is kept continuously wet for as long as 12 months and then stored, without drying, in sulfate solutions that the increase in resistance, as compared with specimens water cured 20 days, is slight.

From the results of the work to date, it seems clear that for water-cured concrete for exposure to the action of sulfates that two distinct phases of the curing period should be given consideration. The first of these is the length of time the concrete is kept moist, and which ordinarily is referred to as curing; while the second of these is the treatment following the curing period proper, and to which very little attention generally is given, although, as shown, correct handling at this time is very evidently of prime importance for all concrete to be used in sulfate waters. Regardless of the length of time cured under moist conditions, concrete must subsequently be allowed thoroughly to dry and harden in the air if great resistance to attack is to be expected. It cannot as yet definitely be stated how long this drying period should continue in order that the resistance be raised to the most practical limit, although it is evident that during the air-storage period, resistance continues to increase for a matter of some weeks. Because of this, in lieu of more exact data at the time, this shipping of freshly made, or "green," concrete tile onto a job should in no case

be permitted by the engineer in charge, while all stock piles should be increased by the manufacturer to a point that will insure all tile being at least several weeks old before installation by the purchaser, as the older the tile are when installed perhaps the better.

RESISTANCE OF STEAM-CURED CONCRETE TO SULFATE WATERS

Steam has been used for many years to accelerate the curing of concrete, and also in concrete work to maintain temperatures well above freezing during cold weather. In the manufacture of concrete drain tile in Minnesota, it is probable that steam first came into use more as a factor in year-round production than for any other reason, for with the cold winters common here, some means of heating the curing rooms is, of course, necessary during the winter months. The boilers used to steam-cure tile operate under a low pressure, only enough steam being put into the curing rooms to keep them fairly humid, which results in curing the tile in a temperature rarely exceeding 100°F. This is ordinarily what is meant by steam curing, as applied to drain tile, and differs greatly from curing in water vapor at, or near, the normal boiling temperature of 210° F. for water.

In line with the investigations at University Farm, experiments are under way to determine the resistance to sulfate waters of concrete cured under various conditions in steam and water vapor of different temperatures. The results of some of this work are shown in Figs. 6, 7, and 8, in which length increases of cylinders cured in steam at 210° F. are compared with similar specimens cured in distilled water. It will be

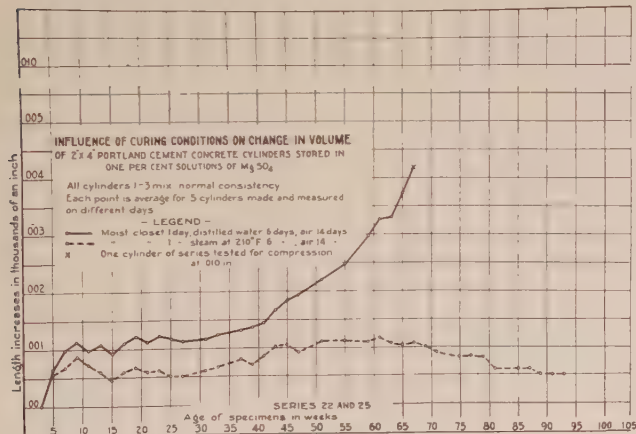


Fig. 6

noted that in every instance the steam-cured specimens are making by far the best showing. That there actually is a marked difference in favor of the physical condition of the steam-cured cylinders is borne out by the general appearance of the specimens, and by such compression tests as have been made to date. (See Table 3.)

STRENGTH OF STEAM-CURED CONCRETE

The data relative to the influence on the strength of concrete cured in water vapor of different temperatures under different conditions are very meager. There seems to be considerable difference of opinion among workers in concrete as to the general merits of steam curing. Because of this, it was necessary to outline a series of experiments that would show both the relative resistance to sulfate waters of concrete cylinders variously cured in water vapor, and the influence on the strength of the material as well. Some of the results of this phase of the work have been plotted in Figs. 9, 10, and 11.

Fig. 9 shows the results of 28-day compression tests

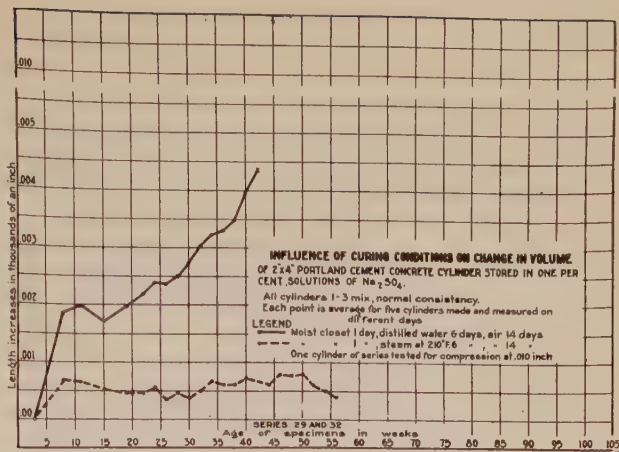


Fig. 7

of concrete cured at early ages in water vapor of temperatures of 100° F., 155° F., and 210° F. It is evident from these curves that no gain in strength follows from applying water vapor, at any of these temperatures, to the concrete the first 12 hours after it is made, but, on the contrary, the concrete is considerably weakened by so doing, especially in the higher temperatures. As a matter of fact, at a commercial plant, it is probable the product would test stronger were the curing rooms closed when filled and no steam applied until the following morning, except as might be required to prevent freezing.

Fig. 9 shows the strength curve for the cylinders cured at 210° F., not only lower than the curve for those cured at 155° F., but also lower than those cured at 100° F. The cylinders for each of these temperature curves were made on different weeks, as the object of these particular series was not so much to obtain a direct comparison of the influence of different temperatures on strength as to show how the strength was affected by applying water vapor of different temperatures to concrete at early ages; consequently, these curves are not strictly comparable for strength as are the cylinders forming the basis of Fig. 10. It will be noted in Fig. 10 that the strength of the cylinders cured in steam at 210° F. show no evidence of being materially stronger than those cured at 155° F. It is therefore apparent, regardless of the influence on resistance, that solely from the standpoint of strength, nothing is gained by curing in water vapor at a temperature much above 155° F.

Fifty batches of concrete cylinders, made on 50 different days, of the same type used in these steam-curing experiments, were stored in water after 1 day in the moist closet. The average compressive strength

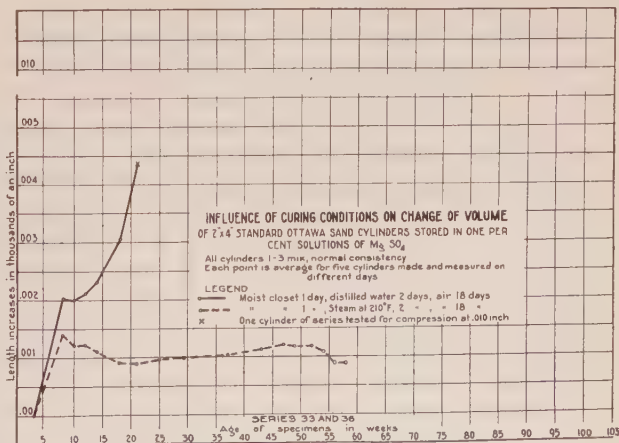


Fig. 8

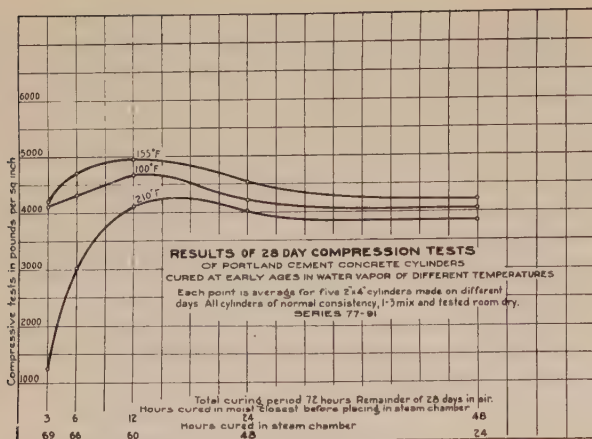


FIG. 9

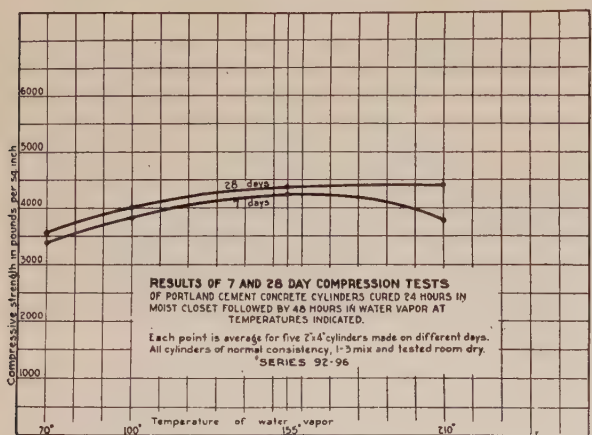


FIG. 10

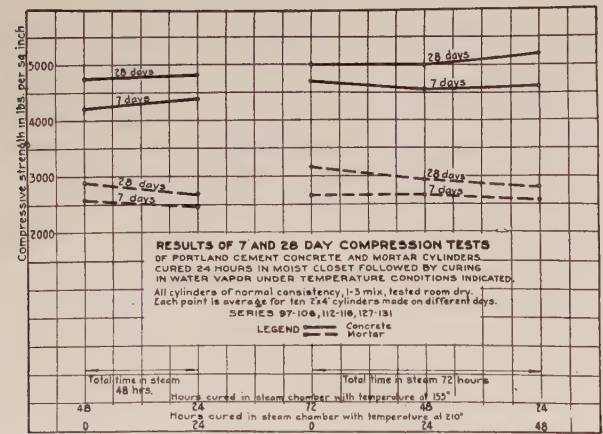


FIG. 11

of the water-cured cylinders in lb. per sq. in. at 7 days and 28 days was, respectively, 3120 lbs. and 4610 lbs.;

while the average compressive strength of the cylinders from 20 batches of cylinders of Figs. 9, 10, and 11, cured 1 day in the moist closet and 2 days in water vapor at 155° F., was 4150 lbs. at 7 days and 4580 lbs. at 28 days. It is evident then, in this work, that curing 2 days in water vapor in a temperature of 155° F. produced concrete nearly 50% stronger at 7 days than concrete cured 6 days in water; while the 2-day steam-cured concrete at 28 days just about equaled in strength that cured in water 27 days.

In the graphs in Fig. 11, the strength of both concrete and mortar cylinders cured 48 and 72 hours in water vapor at 155° F. is compared with that in which a combination of temperatures of 155° F. and 210° F. has been used. It will be noted with the two types of cylinders that in both the 48-hour and in the 72-hour curing the strength results vary so little as to lie within the limits of reasonable variation. It seems fair to conclude from this that, if properly done, little or no strength need be sacrificed in order to steam-cure concrete drain tile at a temperature near the boiling-point of water, if the work that is now under way proves conclusively that the value of such treatment for developing resistance to sulfate waters is as great as now indicated by these earlier experiments.

TABLE I
Time required for 2" x 4" portland cement mortar and concrete cylinders immersed in MgSO₄ solutions to increase in length .010 in. Each result is average for five cylinders of normal consistency and 1:3 mix, made and measured on different days.

Series	Fineness Moduli	Compressive Strength lbs. per sq. inch		Absorption at 21 days %	Wks. required to in- crease .010 inch				Remarks
		7 days	28 days		Strength of solution				
					¾%	½%	1%	4%	
1	3.00	1850	2840	7.1	25.6	15.0	12.9	15.8	Standard Ottawa sand
3	3.00	1370	2180	11.8	32.1	14.5	10.8	10.4	Minnesota sand screened 20-30
4	3.00	1640	2470	9.3	21.9	12.5	10.8	10.6	Minnesota sand screened 20-30
5	3.10	1310	3150	8.6	34.2	22.7	15.6	15.1	Minnesota sand shale removed
6	4.67	2700	4250	6.2	44.5	35.4	23.8	19.8	Minnesota sand pit run and pebbles passing ¾ in.
9	4.67	3340	4900	5.3	50.0	32.1	30.5	30.5	Minnesota sand same as Series 6 except shale removed.
Ave..	3.57	2035	3300	8.1	34.8	22.0	17.4	17.0	

TABLE 2
Effect of different strength solutions of MgSO₄ on compressive strength 2" x 4" portland cement mortar and concrete cylinders of normal consistency and 1:3 mix. Each result is average for 5 cylinders made on different days.

Series	Age	Breaking strength (Lbs. per sq. in.)					Strength Ratios				
		Strength of Solutions					Strength of Solutions				
		0%	1/4%	1/2%	1%	4%	0%	1/4%	1/2%	1%	4%
1	17 wks.	3871	2820	2425	1730	1900	100.0	72.9	62.6	44.7	49.0
3	12 wks.	2450	2120	1555	1490	1010	100.0	86.6	63.4	60.9	41.2
4	12 wks.	2680	1830	1240	1530	1090	100.0	68.3	46.3	57.1	40.7
5	16 wks.	4140	2910	2550	2515	2235	100.0	70.3	61.5	60.7	53.9
6	16 wks.	4095	4060	3660	3481	2970	100.0	99.1	89.4	85.0	72.6
7	17 wks.	5995	5095	4435	4020	3720	100.0	85.0	74.0	67.1	62.1
Ave.	15 wks.							80.4	66.2	62.6	53.3

TABLE 3
Comparative strength of 2-x 4-in. water cured and steam cured portland cement concrete and mortar cylinders and resistance to sulfate waters on basis of strength ratios and change of volume.

Series	Curing conditions following 1 day in moist closet	Compressive strength in lbs. per square inch							Length increase in inches of cylinders in solutions when tested
		In Water				In 1% Solutions			
		At 7 days	At 28 days	Age in weeks	Test	Age in weeks	Test	Strength ratio	
25	6 days in water, then air*.....	3230	4170*	44.0	5400	MgSO ₄	5000	92.6	.0018
22	6 days in steam at 210°F., then air*....	3530	3490*	44.0	3640	44.0	3910	107.4	.0010
29	6 days in water, then air.....		2720	52.0	4570	Na ₂ SO ₄	1850	40.5	.0040
32	6 days in steam at 210°F., then air.....		4040	52.0	4420	52.0	4480	101.4	.0006
33	2 days in water, then air.....	1250	1110	32.0	2480	MgSO ₄	1470	59.3	.0100
36	2 days in steam at 210°F., then air.....	1590	1510	52.0	1970	52.0	1850	94.3	.0012

*Note—Cylinders in Series 29, 32 33 and 36 were tested room dry at 28 days while cylinders in Series 22 and 25 were immersed in water at 21 days and tested wet at 28 days. This second immersion evidently amounted to additional curing which had greater effect on the strength of the water cured specimens than on that of the steam cured ones and accounts for the strength of Series 25 being greater at 28 days than Series 22.

What Shall It Be—Concrete Block, Brick or Tile?

BY WILLIAM F. LOCKHARDT

"What is the best product to manufacture?" or "What are the advantages and disadvantages of concrete block, brick, and tile?" are questions frequently asked by prospective concrete products manufacturers who are uncertain as to just which product should engage their attention.

There is, of course, no "best" product to make or sell. Each one has its own peculiarities, serves a certain need, and must be made the subject of a different type of sales appeal. Different manufacturers are specializing in different products, and in each case are making good profits where the manufacturing and selling are being properly handled.

The experience of various manufacturers in making and selling these different products gives us a line on their good and weak points; the various things that must be taken into account with regard to each one. Manufacturing problems, plant investment, selling difficulties, shipping problems, building department attitude, etc., vary with the different products, and the prospective manufacturers should know that these problems exist. That they are not serious is proved by the fact that thousands of manufacturers are operating successful, prosperous businesses, but thought given first to these problems may indicate a different and wiser choice of product to be made, reduce selling problems, and avoid a lot of grief that would otherwise come with the effort to make or sell a product for which the market is not ripe or to which it is not adapted. A general study shows:

The prospective concrete products manufacturer may do either of two things: The first is to make the same type of unit that is now being commonly used in that particular locality, depending upon higher quality, greater strength of finished work or its better appearance, lower cost due to favorable raw material prices or manufacturing methods to gain the market.

The second method is to introduce a new unit, such as the concrete structural tile, for example, or the cinder concrete block or tile, offering either a saving in labor, material cost, etc., as an incentive to use, or the better service and greater adaptability to be had with a local product which is not subject to shipping delays and loss of time in getting additional material, and "specials," particularly if it can be shown that "specials" are not required, or not required to the same extent as with competing materials.

The first method is affected strongly by the type of concrete product heretofore marketed in the locality being considered. If good concrete products have been made, they will have built up for their industry a valuable good-will in the minds of the user, and the work of introducing the product of a new plant will be correspondingly reduced. The new product will for a time at least, profit by the missionary work, and the high repute, of its predecessor.

On the other hand, if that same predecessor be

already in disrepute because of his products' obvious inferiority, the path of the new product is made correspondingly harder, as it will be necessary to sell each individual prospect on the idea that this particular product is superior to the old, and to do so, it will frequently be necessary to go into technical differences of manufacture that are difficult at best to get across to the layman.

The second method avoids most of these difficulties, though at the same time, it conjures up a set of troubles peculiarly its own. The process of introducing a new product is never an easy one, and builders and architects are inclined to be conservative. Carefully planned and executed promotional and sales work, with an abundance of advertising and photos of completed jobs of the same materials in other cities (by preference not too far away) will all help. High building costs, of course, make all who have to do with the construction industry willing to lend a more ready ear than when costs are lower and the older-established materials can still be used at not too great an increase in cost.

How these questions affect the type of unit to be manufactured will be set down for each one.

BLOCK

The block is the oldest and most famous (occasionally infamous) member of the concrete products family. Its advantages are the low initial investment required to start manufacture, large size, the fact that it is well known and therefore needs less introductory effort, and if made of cinder concrete its light weight (30 lb. instead of 50 lb. for the 8-in. x 8-in. x 16-in. size). The wide mortar bed afforded by the thick webs also facilitates laying, while the fact that its surfaces are true planes, not warped by burning, means a further reduction in the labor cost of getting a good job of wall construction and a big saving in stucco. Cinder concrete block have the further advantage of "nailability"—the quality of being able to take and hold a nail like a piece of North Carolina pine board. This greatly simplifies construction work, as far as the nailing of furring strips, plaster or stucco grounds, moldings, and trim of all kinds, etc., is concerned. In some sections of the country, cinder block walls are plastered inside without furring, though it is doubtful if this practice is to be widely recommended as yet.

The disadvantages of the concrete block are pretty much the same as its advantages. The low initial investment required tends to attract competition, frequently of the fly-by-night or back-yard variety. The large size, with greater weight, leads to objection from the brick mason in some cases, though where cinder block are being used there is less complaint on this score. In addition, as stated above, in many places where block are known, their reputation must be admitted as being not altogether of the best. This will occasion a certain amount of sales resistance for a while, but good quality will overcome it. In most localities there is always some demand for block for

foundation work, and it is usually advisable to give thought to at least one block machine in a tile plant.

BRICK

Brick, of course, is universally known and used. Brick will always be used for some purpose, no matter how extensively larger and lighter units are developed to supplant it.

Concrete brick can be made in many places very satisfactorily in light colors where those colors are difficult to obtain in clay, and as a result, sell quite readily at a comparatively high price. Machinery for the manufacture of concrete face brick on a large scale is not available (except by the employment of a number of units of moderate output), so that, generally speaking, the biggest future in concrete brick manufacture is believed to lie in the direction of straight quantity production—the manufacture of a strictly utilitarian unit to supplant the common red clay brick. On this basis, it is possible in many localities to undersell clay brick by a substantial margin.

Cinder concrete brick are somewhat lighter in weight than clay brick, and therefore meet with a good reception from the mechanic using them. Like cinder concrete block or tile, nails can be driven into them, a very important feature. Concrete brick have the fire resistance of the concrete from which they are made; that of cinder concrete brick is particularly high. Well-made cinder concrete brick have passed the New York Building Department tests, which call for twenty alternate freezings and thawings without deterioration, and in some cases have shown a gain in strength during the tests.

Disadvantages. There are many disadvantages, real and imaginary, to be overcome in the concrete brick field, the same as in any other line. The outstanding one is density, or the lack of high absorption—"suction" the bricklayer calls it. Clay brick, as a matter of fact, have a higher absorption than is permitted in most building codes, but the bricklayers are used to them, and they accordingly expect the brick they have to use to have enough "suction" to give the mortar what is sometimes called a "dry set"—the term applied to the stiffening of the mortar which results when the excess water in the mortar is withdrawn by the brick. When this excessive "suction" is lacking, an unquestionably better grade of masonry results, as this water is needed to properly hydrate the cement in the mortar, but as long as the mortar retains its plasticity, it is difficult to lay up the succeeding courses to any great height. The weight of the superimposed brick tends to force the lower courses out of place, and the brick "float" in the wall.

Overcoming this question of unnecessary and undesirable density is a matter for study in the grading of aggregates principally, and possibly the method of manufacture. Unless it is overcome, however, it undoubtedly constitutes the most serious selling obstacle wherever concrete brick are made.

The heavier weight than clay brick is also an objection, largely imagined. The men complain also that the sharper edges of the cement brick, and the cement they get on their hands, cut their hands badly. It would seem doubtful if any of these objections apply to greater extent with concrete brick than they do with repressed and rough-textured wire cut clay brick, which are certainly heavy and rough enough. That they are largely imagined is proved by the fact that when objections are raised to gray cement brick, the addition of coloring matter to simulate clay brick has been known to end complaint from the men.

The higher plant investment required for the quantity production of brick is also a protection against the inroads of the fly-by-night operator, so that while the initial investment is higher than for the other two products we are discussing, it is not completely a disadvantage. An adequate supply of raw material must also be available, or else it will be necessary to charge off a heavy sum every year for depletion of raw material supply. The volume of material consumed is enormous.

In addition, many cities require of new materials of construction tests that it would be extremely difficult for common clay brick to meet today. For example, while the maximum allowable absorption in a certain eastern city is set at 15% in 48 hours, laboratory tests on nine average clay brick that the writer took from a building under construction showed an absorption higher than 17% in the first 15 minutes. The 48-hour absorption was practically 20%. Such a figure would utterly condemn a concrete brick, though taken as a matter of course in clay brick, because clay brick have stood the test of time. This attitude of mind on the part of the building inspector, mason contractor, and others must be recognized frankly and due allowance accordingly made in determining the quality of product to be made, and in estimating the amount of selling effort that will be required to dispose of the output of a plant large enough to be able to manufacture year in and year out in competition with clay.

TILE

The youngest member of the concrete products family is the light weight concrete structural tile. It has many advantages. It is lighter than block, and therefore less likely to incur the enmity of the mechanic. It is so designed that a hand grip is provided for the mason, to enable him to handle and lay it with one hand, while keeping the trowel in the other, just as when he is laying brick. It bonds readily into brickwork where a face brick veneer is required. As it is usually made 8 in. wide and 12 in. long, it is possible to lay up both 8-in. and 12-in. walls with the same unit by laying the 12-in. dimension parallel to the face of the wall, or across the wall, as may be required. Records of as high as 700 tile per man per day have been established in laying, though this figure is probably 100 to 150 higher than would be had by skilled workman under normal conditions. As each tile displaces six brick, however, even 500 per man would be the equivalent of 3000 brick; the saving cost is apparent.

Concrete tile are equivalent in wall volume to one-half a block, but their weight is substantially less than one-half that of a block; there is a saving in hauling costs by reason of the greater number that it is possible to load on a truck. Where the tile are made of cinder concrete, this number can be still further increased. In many places, where the manufacturer carries a sufficiently large reserve stock to enable him to send out only well-cured tile, they are shipped in back-dump motor trucks, and dumped at the site of the building the same as brick. With good, sound tile the loss is reported by some manufacturers to be as low as 1%, for suburban work, where the tile are dumped on earth or dirt roads; the breakage would be higher were the tile regularly dumped on a concrete sidewalk or a granite block pavement.

Disadvantages. The principal disadvantage in the manufacture of this unit is the fact that it is a new proposition in many parts of the country, and innovations are usually looked upon with suspicion in the building industry. This simply means that special thought must be given to an energetic and intelligent

promotion of this unit, for once a builder has had a chance to use it, he will almost invariably swear by it. More pioneering must be done for concrete tile than for either of the two units previously described, but in many quarters, it is felt that when the light weight structural tile is established, it will to a very large extent supplant the larger and heavier block unit.

The layman (and the building inspector is too frequently to be included in this class) is inclined also to regard the relatively thin webs of the concrete structural tile with suspicion, and only consistently high tests can overcome this attitude.

As two tile are equivalent to one block, it can be seen that two pieces have to be handled in the tile plant as against one in the block plant; careful planning

and skilful management are needed if a proportionate profit is to be had.

* * *

This sums up the outstanding points for and against each of the leading concrete building units. As before stated, there is no "best" unit to make for all conditions. Each town constitutes a separate problem, to be solved only after giving due thought to all the factors which may affect the introduction of these three units. The one unit that then seems to have the greatest opportunity to save in construction costs or to fill an existing unsatisfied demand, is the one to be chosen, with a fair appreciation of the fact that success over a period of years can be had only by consistent intelligent hard work.

Tests of Impure Waters for Mixing Concrete

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Strength tests of portland cement concrete were made at ages of 3 days to $2\frac{1}{3}$ years using mixing waters of a wide range of types, many of which were thought to be unsuitable for use in concrete. Sixty-eight samples of water were tested in two different investigations; 52 samples were collected from different sections of the country; 14 were from the Chicago district. Among the waters tested were sea and alkali waters, bog waters, mine and mineral waters, waters containing sewage and industrial wastes, and solutions of common salt. Tests of fresh waters (including distilled) were made for purpose of comparison. About 6000 tests are included in this report. Reference is made to a number of other investigations on related subjects.

Series 137: 50 samples of water were used in 1:4 concrete of relative consistency 1.10 and tested after curing under the following conditions:

- (a) Moist room tested at ages of 3 days to $2\frac{1}{3}$ yrs.
- (b) Moist room 28 days, then in air of laboratory, tested at 3 mo. to $2\frac{1}{3}$ yrs.

Series 138: 18 samples including sewage and trade wastes from the Chicago district were used in concrete cured in moist room as follows:

- (a) 1:7, 1:5, 1:4, 1:3 and 1:2 mixtures; relative consistency 1.00, tested at 28 days.
- (b) 1:4 concrete mix, relative consistency 0.90, 1.00, 1.10, 1.25, and 1.50, tested at 28 days.
- (c) 1:4 concrete mix; relative consistency 1.00, tested at 3, 7, and 28 days, 3 mo., 1 and $2\frac{1}{3}$ yrs.
- (d) 1:3 standard sand mortar, tension tests of briquets and compression tests of 2 by 4-in. cylinders at ages given in (c).

Concrete and mortar tests were made in accordance with standard methods. In general, 5 to 10 concrete specimens, and 5 mortar specimens were made in a set on different days.

Time of setting and soundness tests of cement were made with each sample of mixing water.

The principal conclusions from these tests are:

(1) In spite of the wide variation in the origin and type of the waters used, and contrary to accepted opinion, most of the samples gave good results in concrete. This result seems to be due to the fact that the quantity of injurious impurities present is quite

small. The following samples gave concrete strengths below the strength-ratio of 85%, which was considered the lower limit for acceptable mixing waters: Acid waters, lime soak from tannery, refuse from paint factory, mineral water from Colorado, and waters containing over 5% of common salt.

(2) The quality of a mixing water is best measured by the ratio of its 28-day concrete or mortar strength to that of similar mixes with fresh water. While the lowest permissible strength-ratio is a matter of judgment, waters giving strength-ratios which, in general, fall below 85% should be considered unsatisfactory; if only isolated tests are made, 80% should be the limiting value. The time-of-setting test appears to be an unsafe guide as to the suitability of a water for mixing concrete.

(3) Neither odor nor color are any indication of quality of water for mixing concrete. Waters which were most unpromising in appearance, gave good results. It may safely be said, however, that any natural water which is suitable for drinking can be used without question for mixing concrete.

(4) Distilled water gave concrete strengths essentially the same as other fresh waters.

(5) Bog waters which were thought to be unsuitable for mixing concrete generally contained only small quantities of foreign materials and gave good results. The strength-ratios for the individual samples were seldom below 90%.

(6) Sulfate waters produced little or no ill effects until an SO_4 concentration of about 1% was reached. For a concentration of 0.5%, the average reduction in strength was about 4%; a concentration of 1% was required to produce a reduction in strength of more than 10%.

(7) Concrete mixed with sea water (about 3.5% salts, mostly sodium chloride) cured in the moist room gave higher strengths than fresh-water concrete at ages of 3 and 7 days; at 28 days and over, the strength-ratios for sea water ranged from 80 to 88%. Air-cured concrete mixed with sea water was lower in strength than similar fresh-water concrete at 3 months, but showed

a recovery in strength at later ages, and gave strengths equal to that obtained with fresh water. (In spite of the unsatisfactory strength results, it seems unwise to use sea water in reinforced concrete construction, particularly in the tropics, on account of danger of corrosion of reinforcement.)

(8) Synthetic sea water gave concrete and mortar strengths similar to natural sea water.

(9) Concrete mixed with water from the Great Salt Lake (about 20% sodium chloride) gave strength-ratios from 65 to 77% at ages of 28 days and over. This water is not satisfactory for mixing concretes, unless allowance is made for about 30% reduction in the assumed strength.

(10) Water from Devil's Lake, North Dakota (0.15% sodium sulfate and 0.15% sodium chloride), gave normal concrete strengths and showed no ill effects.

(11) Water from Medicine Lake, South Dakota (3.5% solution of sulfates, largely magnesium; SO_4 concentration 2.8%) gave strengths similar to that obtained with sea water. The lower strength-ratio was 84%.

(12) Waters from drains and small streams in sulfate districts gave satisfactory strengths at ages up to $2\frac{1}{3}$ years. The lowest strength-ratios were about 90%.

(13) Concrete made with solutions of common salt and cured until test in a moist room showed a slight increase in strength at 3 days for solutions of 10% and less. Solutions of low concentration (1 and 2%) also showed a slight increase in strength at 7 days; after 7 days, however, all concentrations gave material reductions in strength. Strength-ratios as low as 60% were found for a 20% solution at early ages, and for 10% and 15% solutions at the later ages.

Concrete made with salt solutions and cured in the moist room for 28 days, then in air, gave results at 3 months almost identical with that obtained for moist-room curing. For this curing condition, the addition of salt reduced the strength at 1 year about 12%; at $2\frac{1}{3}$ years there was no reduction in strength. The apparently conflicting results for moist-room and air-curing have not been explained.

(14) The use of common salt for the purpose of lowering the freezing point of the mixing water during cold weather should not be permitted; 5% of salt lowers the freezing-point of water about 6° F., but reduces the strength of concrete about 30%.

(15) Mine and mineral waters gave good results in concrete, with the exception of a carbonated mineral water from Colorado, which gave strength-ratios as low as 80%. Pumpage waters from coal and gypsum mines also gave good results in concrete.

(16) Water containing sanitary sewage gave essentially the same concrete strengths as fresh water. Water from the Illinois River, which carries sewage from Chicago, gave strength-ratios at 28 days and 3 months of 83 and 85% for moist-room curing; for air curing, strength-ratios ranged from 92 to 102%.

(17) Waters containing refuse from oil refineries gave erratic strengths. These samples generally gave strengths near normal, but in some cases material reductions in strength were found. Setting time of cement with one water sample was, initial 10 hours, final 42 hours.

(18) "Bubbly Creek" water, which is highly polluted with wastes from the Chicago stockyards and gave off an offensive odor, showed strength-ratios of about 100% for all ages, mixes, and consistencies.

(19) Tannery wastes generally gave reductions in concrete strength; the lowest strength-ratios were about 80% (lime soak water).

(20) Brewery and soap works wastes gave concrete strengths essentially the same as that of fresh water.

(21) Waste from a gas plant and a corn products factory gave good results; the strength-ratios ranged from 90 to 100%.

(22) Paint factory wastes water gave strength-ratio ranging from 80 to 90%.

(23) A spent plating bath containing sulfuric acid, after dilution to 10 and 20% of its original concentration, gave strength-ratios as low as 85% for the 10% solution and 74% for the 20% solution. For different consistencies both solutions gave about the same strength-ratios which ranged from 88% to 106%. Lower strength-ratios were obtained with the rich concretes than with the lean.

(24) The strength of concrete mixed with all samples of impure waters showed normal increase at 28 days with additional quantities of cement. The impure waters gave about the same strength-ratios regardless of the mix used in the concrete tests. For the usual range in mixtures (1:5 to 1:4) the strength increased about 1% for each 1% additional cement.

(25) There was a marked reduction in strength of concrete with increase in quantity of mixing water, both for fresh and impure waters. Increasing the quantity of mixing water 1% reduced the strength of concrete about the same amount as if the quantity of cement were reduced 1%. A comparatively slight increase in quantity of mixing water produced a greater reduction in concrete strength than that caused by the use of the *most polluted* mixing water that is ordinarily encountered. These tests show the importance of the water-ratio strength relation in concrete which has been pointed out in numerous other reports from this laboratory.

(26) The effect of impure waters was, in general, independent of the consistency of the concrete. Acid waters from a spent plating bath gave somewhat higher strength-ratios in the wetter concretes.

(27) The strength of concrete cured in a damp condition at normal temperatures increased with age for both fresh and impure waters. The strength was approximately proportional to the logarithm of the age at test.

(28) The effect of impure mixing waters on the tensile and compressive strength of 1:3 standard sand mortar at ages of 3 days to $2\frac{1}{3}$ years was generally similar to that on the compressive strength of concrete. In the mortar tests a few waters gave somewhat higher strength-ratios, and one water gave a somewhat lower strength-ratio than was obtained in concrete.

(29) The percentage of water required for normal consistency of cement when mixed with the impure waters was, with few exceptions, about the same as for fresh waters. Water from Great Salt Lake, solutions of 5 to 20% of common salt, refuse from an oil refinery, Medicine Lake water, and acid water from a spent plating bath, required somewhat higher percentages for normal consistency than fresh water.

(30) The time of setting of portland cement mixed with the impure waters was about the same as for fresh waters, however, there were some notable exceptions. In most instances, the samples giving low concrete strength-ratios were slow setting. On the whole, the tests show that time of setting is not a satisfactory test for suitability of a water for mixing concrete.

(31) None of the impure waters caused unsoundness of the portland cement when subjected to the standard test over boiling water.

(32) Most specifications for water for mixing con-

crete are so worded that they would, if strictly enforced, exclude nearly all but rain water and distilled water; these tests have shown that almost any impurity may be present without necessarily producing ill effects. The important point is not whether impurities are

present, but do the impurities occur in *injurious* quantities?
(33) The effect of sugar and similar compounds were not studied; earlier tests have shown that these compounds are most detrimental and must be avoided.

Better Concrete: Water-Cement Ratio

By D. H. DIXON
VICE PRESIDENT TURNER CONSTRUCTION CO., N. Y. C.

"The water content is the most important element of a concrete mix. . . . This shows the absurdity of our present practice in specifying definite gradings for aggregates and carefully proportioning the cement, then guessing at the water." So says Prof. Duff A. Abrams, in his "Design of Concrete Mixtures." But it takes a long time for a newly discovered fact to influence the daily work of the rank and file; to get that fact across so that engineers may safely count upon a better quality of concrete and figure higher stresses in their buildings. The accompanying article from the *Turner Constructor*, published by Turner Construction Co. for its employes, shows how the company is going about it to establish good water control practice on the job.

—Editor.

Some improvements in methods of doing work are costly. Very fortunately, the quality of concrete can be greatly improved by so simple and inexpensive a thing as the elimination of unnecessary water from the mix.

The bad effect of using an excessive amount of water in mixing concrete had been known, but was never expressed in a way to bring the crime of excessive water home to most of us until Prof. Duff A. Abrams published his paper on the "Design of Concrete Mixtures" in 1918. His study on the concrete making properties of an aggregate, as expressed by its "fineness modulus," is of great interest, but of even greater practical value is his forceful expression of the effect the quantity of water used in the mix has on the strength of the resulting concrete.

He shows that if the cement used is of uniform strength, then the strength of concrete, such as we use in building work, is determined by the volume of mixing water expressed as a ratio to the volume of cement. This ratio he calls the water-cement ratio.

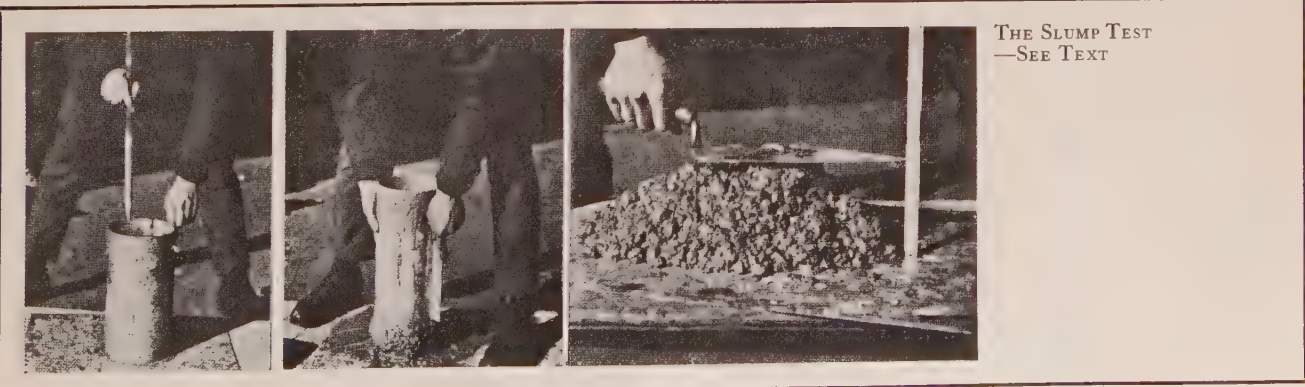
For example, if a batch of concrete contains 1 cu. ft. (7½ gal.) of water, 1 cu. ft. (1 bag) of cement, 2 cu. ft. of sand, and 4 cu. ft. of gravel, the water-cement ratio for this batch is 1. If, while still using 1 bag of cement in the next batch, the water is reduced from 7½ gal. to 7 gal., the water-cement ratio then becomes .93.

The "fineness modulus" theory enables us to so grade the aggregate as to get the desired plasticity with the least amount of water and cement, but, even with perfect grading, the limit is reached when any further reduction in water results in a concrete that is not "workable."

	1 Gallons of Water	2 Water-Cement Ratio	3 Strength of Concrete, lbs. per sq. in.
Batch 1.....	7½	1	2000
Batch 2.....	8	1.07	1764
Batch 3.....	9	1.21	1320
Batch 4.....	10	1.34	996

For reinforced concrete building construction the concrete must have a plasticity expressed by a cylinder slump (explained below) of about 7½ in., and with fairly well graded aggregate, this means a water-cement ratio of about 1. For mass concrete, where it is not necessary that the concrete shall flow into place around reinforcing rods, etc., a less plastic concrete can be used, with the result that in mass concrete the water can be reduced, giving an equally strong concrete with less cement.

The accompanying table shows the approximate effect produced on the strength of concrete by changing the amount of water used in the mix. In each of the four batches reported in the table, 1 bag of cement is mixed with 2 cu. ft. of sand and 4 cu. ft. of gravel. Cement, sand, and gravel are exactly the same in each batch. The only variable is the quantity of water put into the different batches, which is given in gallons in column 1. The 2nd column gives the water-cement ratio in each batch, resulting from the amount of water used, and the 3rd column gives the



strength of the concrete, as measured by cylinders stored in damp sand and tested at 28 days.

Let us express the facts contained in the table in everyday terms, assuming we are mixing batches each containing 4 bags of cement. Put 10 pails of water (if each pail contains 12 qt. of water) into the mixer and get 2000-lb. concrete, but if you put $10\frac{2}{3}$ pails of water into the mixer, then, by adding this $\frac{2}{3}$ of a pail of unnecessary water, you reduce the strength of the concrete from 2000 lb. per sq. in. to 1764 lb. per sq. in., and if, instead of using 10 pails of water, you put 12 pails of water into the mixer, then you reduce the strength from 2000 lb. per sq. in. to 1320 lb. per sq. in.

These results are truly surprising, and you naturally wonder why we have been putting an unnecessary amount of water into concrete for the past twenty years when, at any time in that period, we could have made such a remarkable improvement by reducing the amount of water to the quantity required to give the necessary plasticity. Two reasons may be given. Until Professor Abrams gave us the water-cement ratio theory, the effect of the water used in the mix was never sufficiently emphasized. But perhaps an equally important cause for our negligence has been the fact that no trouble has been experienced with the carrying capacity of floors and columns built from wet concrete.

It is the latter fact which will make it difficult to get the experienced superintendent or foreman, who has been building satisfactory buildings from wet concrete for twenty years, to take kindly to new-fangled notions of control of water in the mix. He has built good buildings for twenty years with wet concrete, and why should he be asked to start in making mud pies (slump tests).

The primary purpose of this memorandum is to point out to the man who has this attitude of mind that, if engineers were going to keep on designing reinforced concrete building with the unit stresses now used, and were going to continue to specify a 1:2:4 mix of concrete with these stresses, there would be little practical use in attempting great refinement in the control of water in the mix—his attitude of mind would be, to some extent, justified. His attitude is wrong, however, as he overlooks the fact that what we are after is to make a stronger concrete with an equal amount of cement, so that in the future, engineers will figure higher stresses when they specify 1:2:4 concrete thus reducing the quantity of concrete used in a building, to the advantage of the concrete industry and of the entire building public.

But, before engineers figure higher stresses without increasing the cement factor, they will want to know that such stronger concrete can be made with regularity and certainty under job conditions, and to help meet this demand for an assurance of consistent quality in our concrete, we use the "slump test."

If all the sand and all the gravel delivered on a job contained the same amount of moisture, the slump test would not be necessary, except, perhaps, as an auxiliary check on the inspection and measurement of the materials put into the mixer for each batch. But, unfortunately, sand and gravel as delivered are sometimes almost dry and sometimes are very wet. On one recent job in New York, the moisture in the sand varied from 2.2% to 7.3% of the weight of the sand; while the moisture in the gravel varied from 1.4% to 4.1% of the weight of the gravel. This variation in moisture content of the aggregate makes it impossible to keep the water-cement ratio of each batch the same by putting the same amount of water into the mixer from the water barrel. The quantity of water taken from the barrel must be varied as the aggregate is

wetter or drier, because the water-cement ratio is determined by the total amount of water in the batch, including both water put in from the barrel and water contained in the aggregate. How are we to know that we are not getting too much water into batches made from moist aggregate?

If consistent strength is to be maintained, it is essential that we do know that the concrete, as delivered from the mixer, contains approximately the correct amount of water. We do not get the results of strength tests until too late. The slump test is, to date, the best method we have for checking the water content and also, to some degree, the uniformity of the mix at the time the concrete is placed.

The following description of the slump test, with the accompanying pictures, is taken from "Turner Construction Company Job Bulletin No. 15—1921, 'Control of Water in Concrete—Slump Tests.'" We still use the cylinder slump, as described in our Bulletin No. 15—1921. Since our bulletin was written, the American Society for Testing Materials has replaced the 6 x 12 cylinder by a truncated cone 12 in. high, with top diameter of 4 in. and bottom diameter 8 in. A given concrete will show about $\frac{2}{3}$ as large a slump with the truncated cone as with the 6 x 12 cylinder. The distinction between the truncated cone slump and cylinder slump must be kept constantly in mind, because descriptions of tests up to very recently have used the cylinder slump (Prof. Abrams, in his "Design of Concrete Mixtures," used the cylinder slump), while current technical articles generally, but not always, give slump as measured using the truncated cone.

In a 4-bag batch of concrete such as we use in buildings, 8 quarts of unnecessary water reduces the strength of the concrete over 10% and 24 quarts of unnecessary water reduces the strength 35%.

"The slump test is made as follows: A metal cylinder 6 in. in diameter and 12 in. high is set on a level metal plate and filled with concrete. The concrete should be taken from a part of the work being poured and be placed in the cylinder in three approximately equal layers and each layer tamped twenty-five (25) times with a $\frac{3}{4}$ in. iron rod 21 in. long pointed at the end, as shown in Fig. 1. The metal cylinder is then removed by a direct vertical lift, allowing the concrete to slump into a cone-shaped puddle. See Fig. 2. The difference in inches between the height of the concrete in the puddle and the original height (12 in.) is the slump. It will be seen that the wetter the concrete the greater the slump will be. For the sand and gravel concrete used in New York the slump will probably have to be about $7\frac{1}{2}$ in. for concrete used in our building work. Fig. 3 shows how the slump is measured, showing a $7\frac{1}{2}$ in. slump.

The superintendent must determine the minimum consistency (minimum wetness) of the mix necessary so that the concrete will readily flow into place around the reinforcement (in a beam; for example, when the beam reinforcement is struck by a tamper). Having mixed a batch to what, in his opinion, is the proper consistency he should make several slump tests to determine the amount of slump for this mix and should then make slump tests at least once a day in order to know that the mixer gang is maintaining the consistency he has established as desirable. Results of slump tests are to be reported on daily construction reports.

The slump test cannot be considered an accurate indication of the amount of water in the mix, but the approximate results obtained by its use will be found of great value in correcting the wide variation we now have in the water content of concrete with corresponding fluctuation in strength.

Nothing in this memorandum is to be construed as advising an attempt to place concrete of a drier consistency than will readily flow into place around the steel reinforcement with a reasonable amount of spading. It is perfectly proper to use a wetter mix for thin partitions and other non-bearing members of the structure.

This memorandum is written to emphasize the fact that having

fixed upon concrete of a given consistency as proper for the work, the mix should be supervised so that through carelessness we do not put in more water than is necessary.

Contractors who specialize in reinforced concrete building work have already made considerable progress in reducing the quantity of mixing water. In the fall of 1923, Stanton Walker, of Lewis Institute, conducted tests on jobs of five contractors in New York. These jobs were run under normal conditions, without an effort to secure concrete of unusual quality through the exercise of more than ordinary care in the work. One one of these jobs, the concrete was deposited through chutes. The results obtained in these tests showed that the concrete as placed was stronger than the strength assumed in the design, but, looking to the future, an examination of the data collected shows the possibilities of marked improvement in further control of

water, grading and measurement of the aggregate, etc.

This memorandum has dealt with the effect of only one element (water in the mix) on the strength of concrete. To get the economical and uniform concrete we want for the future, other elements must also be considered. The cement manufacturer must give us a stronger and more uniform cement. The sand and gravel banks must, through better screening arrangements, give us aggregates that are better graded and that are more uniform. Better mechanical devices must be worked out for mixing and placing concrete. All of these improvements will come in time, but with the possible exception of improvements in the strength and uniformity of cement, no one of them will accomplish so much for better concrete as can now be accomplished on our jobs by the simple expedient of keeping unnecessary water out of the mix.



Concrete Dam at Bassano Is of Hollow Type

The real value of irrigation to vast stretches of land sloping down from the Rocky Mountain foothills in Alberta, Canada, has been made clear during the present season through the greatly increased crops made possible by the recently completed Horseshoe Bend dam on Bow river. This dam, which is located at Bassano, a short distance east of the city of Calgary, is considered one of the notable structures of its kind. Its composite character, great length, unusual foundations, and the great depth of water which flows over its crest in flood periods, constitute its noteworthy features. It supplies water to irrigate 400,000 acres of land.

The dam consists of a long and high ear, with an embankment on the south bank of the river, and a reinforced concrete spillway in the existing river channel, connected at the northerly end with the canal headgate structure on the main canal.

The earthen embankment has a maximum height of 45 ft., and is 7200 ft. long. Its construction involved the transportation of over 1,000,000 cu. yds. of material from the main canal cut on the opposite side of the river. The dry slope of the dam is 3 to 1, and the wetted slope 4 to 1, paved with concrete slabs. The top width averages about 40 ft., with a freeboard of 9 ft. above to water level.

The spillway portion of the dam is a reinforced

concrete structure of the so-called Ambursen hollow type. It is 720 ft. long, with a maximum height of 40 ft. to the crest, above which a depth of water of 11 ft. is controlled by 24 structural steel sluices of the Stoney type, each having 27 ft. clear span, and the whole having a maximum capacity of 110,000 cu. ft. per sec. The maximum height of the structure is 65 ft. from the lowest foundation. A roadway, 10 ft. wide, extends across the top of the dam.

The canal headgates form an integral part of the spillway structure at the northerly end, and consist of five steel gates, each 20 ft. wide, which control the discharge into a canal, having a carrying capacity of 3800 cu. ft. per sec. and a water depth of 11 ft. The gates on the spillway and headgate structure can be operated either by hand or by electricity. The power plant, of 125 h. p., consists of a vertical turbine with direct connected generator, installed inside the dam.

The construction of the dam included the excavation of about 1,250,000 cu. yds. of material, the placing of 55,000 cu. yds. of concrete, and 3,000,000 lb. of reinforcing steel, together with about 500 tons of sub-structure steel. It cost, in its entirety, approximately \$1,500,000.

This dam and its appurtenances form the control works for one of the large irrigation systems on the North American continent, which is owned and operated by the Canadian Pacific Railway Co. It was a very large undertaking, and necessitated the building of 2500 miles of artificial waterways, and the construction of many large and important structures. The earthwork moved in the construction of these works amounted to over 22 million cu. yds., and the various structures, numbering over 13,000, include drops, headgates, flumes, inverted siphons, bridges, etc., to a large extent built of reinforced concrete.

Concrete Water Barge Resists Sea Water



FIG. 1—MAKING REPAIRS ON CONCRETE WATER BARGE. TANKS ON OPPOSITE SIDE ARE FILLED WITH WATER, WHICH RAISED THE SIDE TO BE REPAIRED OUT OF THE WATER, ENABLING THE WORKMEN TO GET AT THE HOLE

FIG. 2—CONCRETE DECK SHOWING METHOD OF ATTACHING PIPES, MANHOLES, ETC.

THE INSERT SHOWS THE BARGE BEING TOWED

What is believed to be the first concrete water barge built on the Pacific coast was constructed for Harvey & Roberts, of San Francisco, and has proved entirely satisfactory. The barge is used to supply deep-water vessels and coastwise craft in the San Francisco Bay with fresh water.

The barge is 65 ft. long, with 22 ft. beam and 10 ft. draft. The capacity of the barge is 42,000 gal. of water, which is stored in four tanks.

The thickness of the bulkheads, walls, and deck is $2\frac{1}{2}$ in., with extra thickness at such points as the guards, top and bottom, and the tugboat fenders, and at the deck where the fittings are mounted.

The bulkheads are buttressed with vertical stiffeners approximately $4\frac{1}{4}$ in. thick x $11\frac{1}{2}$ in., standing out from the bulkhead on each side. On the center line bulkhead, the stiffeners are spaced not to exceed 3 ft. 9 in. on centers, and on the transverse bulkheads, 3 ft. 8 in. on centers.

The sides have frames of the same construction as the bulkheads, but the depth is approximately 12 in. The floors across the bottom are 12 in., and the deck beams 10 in., worked in the form of an arch, completing the square when taken in conjunction with the stiffener on the centerline bulkhead.

The concrete consists of one part cement to $\frac{2}{3}$ part of sand, and $1\frac{1}{3}$ parts of burnt shale. The shale was used to save weight, and was equal to that manufactured by the Los Angeles Pressed Brick Co. for use

in building concrete vessels of the best grade crushed and screened, running from sizes of $\frac{3}{16}$ in. to $\frac{3}{8}$ in.

All interiors of water compartments and all external surfaces were given a trowel finish. The deck surface was finished with a wooden float after the form work was removed and surfaces were finished with cement mortar made of equal parts cement and sand while the concrete was still green.

The water is carried in four tanks, placed nearly amidships, the tanks being formed by a main central bulkhead running from end to end of the vessel, and three transverse bulkheads from side to side.

The bulkheads are tight throughout except that the centerline bulkhead has limbers forward of the forward bulkhead and aft of the after bulkhead to permit any bilge water to flow to one side or the other to the bilge pumps.

The web frames are continuous in each tank and have $2\frac{1}{2}$ -in. pipe limbers to permit the water in each tank to flow to the pump suction in that particular tank.

The deck slab and side are swelled out to form the fenders about 8 in. clear of the barge all around. The guard is faced with a troughed iron, 9 in. x $\frac{5}{8}$ in., held in place with anchor bolts bedded in the concrete.

The corners of the barge along the bottom are swelled out to form a lower guard, and the sides of the barge have vertical tugboat guards fitted at intervals of 7 ft. 6 in. and the lower guard worked into these vertical guards.

The vertical tugboat guards have a galvanized curb bar bedded into the face, and the vertical guards come opposite the frames inside of the barge. The corners of the barge have galvanized curb bars embedded in the concrete to protect them against abrasion.

Round rods and triangular wire fabric were used for reinforcing.

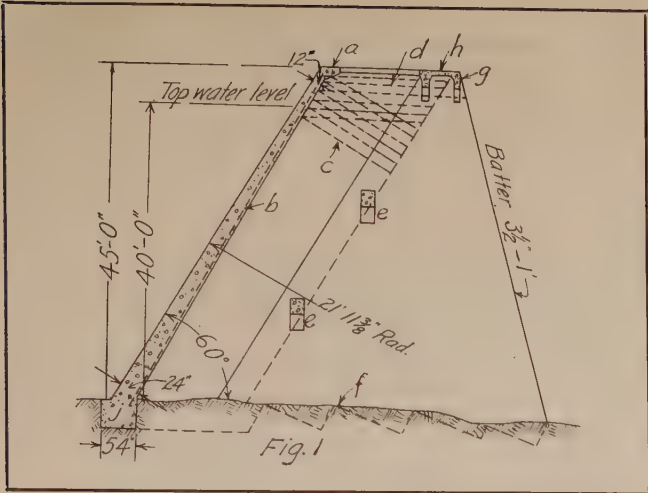
The dimensions of the barge are as follows: Depth from the top of the deck at the side to the bottom of the barge outside, 9 ft. 3 in.; displacement, light, 94 tons; displacement, loaded with 156 tons of water, 250 tons; draft, light, 3 ft.; draft, loaded, 7 ft. 6 in.; total length of water tanks in the clear, 29 ft. 9 in.; depth at the end of the barge, 1 ft. 6 in.; length of the run, 12 ft. 6 in.

Advocates of concrete barge construction were elated over the record made in the repair of this barge recently when a hole in the side was repaired by two cement finishers in two hours at a cost of \$9. Similar work on a wooden ship would have taken a week, and cost not less than \$500, it was estimated.

The barge was struck by a wooden fender of a tug that was towing it in the bay. A hole, approximately 2 ft. long and 1 ft. wide, was cut into the side amidships above the water-line between two frames. The barge was towed to a nearby slip, and two men from the Healy-Tibbitts Construction Co. made the repairs.

The concrete has held up perfectly since the barge was constructed in February, 1920. It has been subjected continuously to the action of salt water. None of the compartments have leaked a particle. In making patches, made necessary when the barge was struck by other craft, a mixture of equal parts of cement and sand with a consistency of putty was used. It is never necessary to dock this barge in making repairs, all that is necessary is to fill the tanks on the opposite side to which the repairs are to be made, and the side will be raised out of the water, as shown in the accompanying illustration.

In order to make the concrete non-porous, the architect, David Dickie, who designed the barge, used kiesel guhr or diatomaceous earth, the percentage of this material being 5% by volume.



Arched Concrete Dam for Tasmanian Barrage

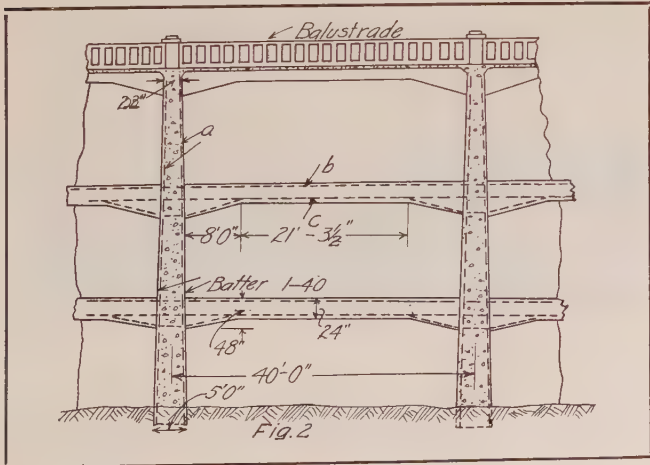
BY MAJOR JOHNSTONE-TAYLOR
LYMM, ENGLAND

Although an island of quite small size, Tasmania possesses, in what is known as the Great Lakes scheme, quite a considerable amount of water power which has been recently developed.

In connection with extensions thereof a new dam has been built, the ferro-concrete arch construction having been adopted for the purpose. The structure, which impounds water to a depth of about 40 ft., has a total length of 1080 ft. and a maximum vertical height of 45 ft., and is formed of 27 arches at 40-ft. centers. A range of outlets is built into the center of the dam in place of the more usual spillway.

THE ARCHES

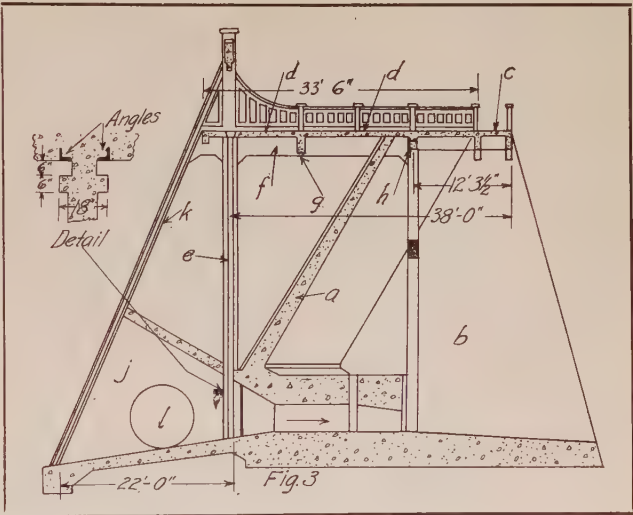
A general section of one of the arches is given in Fig. 1, from which it will be noted that the face has a slope of 60°. The thickness of the crown at the top is 12 in., although it will be observed that there is a lip added at *a*. The thickness is gradually increased to 24 in. at the foot, while a toe of the usual form brings the footing *j* to a width of 4 ft. 6 in. The external radius of the arches is 21 ft. 11 3/8 in., the internal radii being 20 ft. 5 5/8 in. at the base and 20 ft. 6 5/8 in. at the top. The reinforcement is disposed on the underside of the arches, as shown at *b*, extra rods being introduced at the haunches. The latter are arranged 3 in. below the upstream face normal to the 60° in-



clination. The rods used at the haunches are 3/4 in. round, and are variously spaced 12 in. to 7 in. according to the depth from the top, 1/2 in. bars being used for roughly the middle third of the arch. The longitudinal reinforcement consists mainly of 1/2-in. bars at 12-in. centers normal to the upstream face, as at *c*, except for the six rods *d* at the top, which are horizontal.

BUTTRESSES AND TIES

Fig. 2 shows the buttresses and the arrangement and form of the ties. The latter are also seen at *ee* in Fig. 1, which also shows the downstream batter of the buttresses to be 3 1/2 in. to the foot. The side batter of the buttresses, as shown in Fig. 2, is 1-40, the top thickness being 22 in. and the base thickness 5 ft., at which point they are notched into the solid rock, as shown in Fig. 1 at *f*. Plain round bars are used for the reinforcement, these consisting of two vertical 1-in. bars, 6 in. inside the downstream face, as at *a a*; while at each side there is a network of 1/2-in. bars 2 ft. apart, 3 in. below the surface. On the upstream side are four 1-in. rods at the spring line, disposed in the form of a rectangle and bound with stirrups. The ties, *e*, Fig. 1, have a center depth of 24 in., this being increased to 48 in. at the buttress end. The thickness is 18 in. The reinforcement consists of five 5/8 in. bars *b* at the top, and three 1/2-in. bars *c* at the bottom, tied by stirrups at 24-in. centers. The footpath on top, which has an ornamental balustrade, is carried by 9-in. beams, as shown at *g* Fig. 1, the decking *H* being 3 in. thick. The panels, posts, and cap of the balustrade are precast.



OUTLET

Fig. 3 gives a section of the dam through the outlet, the total width of this portion being 38 ft. 9 in., approximately the span of one arch. The arch section will be recognized at *A*, the buttress at *B*, and the footpath at *C*. The latter, it will be noted, is extended upstream in the shape of platform *d* a matter of 33 ft. 2 in. The approach portion of the platform has a width of 18 1/2 ft., extended 9 ft. each side, in respect of the fourth or upstream section *d*¹, so as to constitute an operating platform 36 1/2 ft. wide for the sluices, etc. This platform is supported upon the five reinforced concrete columns *e*, which also form the guides for the sluices, the latter being plain cast-iron gates, hand operated. The flooring of platform *d*, which is 6 in. thick, is carried on beams *f*, 36 in. deep and 9 in. thick; cross beams *g* being 30 in. x 9 in. and cross beam *h* 24 in. x 8 in. The sluice openings *j*, of which there are four, are parallel in a horizontal plane and 7 ft. 10 in.

wide, extending, as will be seen, 22 ft. upstream. The struts *k* are so formed and arranged as to form slides for the fish screens, which normally cover the mouths of the openings. The latter, it might be noted, are connected by the 8 ft. 0 in. diameter openings *l*.

AGGREGATE AND GENERAL CONSTRUCTION

The coarse aggregate was mainly of crushed quarried stone, the fine aggregate being partly sand and partly fine matter from the stone crushers. The proportions adopted were 1:2:4 for the arches and 1:2½:5 for the remainder of the structure, some 10,000 cu. yds. of concrete being placed, mainly by the tower system. The greater portion of the work is founded on solid rock, although decomposed matter had to be excavated at points and filled up with solid concrete. Owing to the fact that the radius of the intrados varies at different elevations, several sets of arch forms were

required for one span. The arch forms supported stringers parallel to the axis of the arch, and these, in turn, supported sheeting of 4 in. x 1½ in. hardwood, cut to the curve of the arch by a band saw. The sheeting was supported on cleats nailed to the sides of the stringers, so that the face of the sheeting was flush with that of the stringers. The braced arches were supported by reversed wedges against inclined timbers bolted to the sides of the buttress, and by knocking out the wedges, the forms could be easily released for removal. The radius of the extrados being constant, the inclined stringers were held by bolts cast into the concrete as the arches were erected, the bolts being subsequently removed and the holes plugged. This type of sheeting was found very convenient for placing concrete in narrow spaces, because it could be dropped in place piece by piece as the concrete rose, facilitating the ramming and working of the concrete.

Western Gateway Bridge

The great Western Gateway bridge over the Mohawk River at Schenectady, N. Y., now nearing completion presents numerous interesting features and is unique in that it contains a great curved arch, believed to be the first and only concrete structure of this particular type ever built.

The total length of the bridge is 4,436 ft., 260 ft. of which is taken up by approaches, leaving the actual length 4,176 ft. It is made up of 24 spans, varying in length on the center line of the bridge from approximately 99 ft. to 121 ft.

From the Schenectady approach, the bridge crosses a branch of the Mohawk River at right angles. It then curves decidedly to the right and runs across Van Slyck Island. It next crosses the main channel of the river which is now used as the New York State Barge Canal and after crossing another large island known as Hog Island, another branch of the Mohawk River is crossed to the Scotia, N. Y. approach.

The curve in the arch occurs at the approach of Van Slyck Island from the Schenectady side. Span No. 4 is the first curved span and it extends from pier No. 3 to the triangular shaped pier No. 4 on the island. Piers No. 1, 2, 3, 5, 6, and 7 are set at right angles to the center line of the bridge, while piers No. 8 to 23 inclusive are set on a skew with the bridge so as to make them more nearly parallel with the direction of flow in the channels which the bridge crosses.

The highest point on the bridge is the center of span No. 13 over the barge canal channel where the clear distance between piers is 212 ft. At the center of this span the bridge is approximately 17.5 ft. higher than at the Schenectady approach and 11.8 ft. higher than the approach on the Scotia side.

The center span over the main channel of the river will not be of reinforced concrete but consists of four steel ribs, extending from pier to pier and encased in concrete to give added stability and to give the span an appearance similar to that of the remaining spans of the bridge. From the top of the roadway to the river level at this point the distance will be approximately 52 ft.

The straight sections of the bridge are supported on three reinforced concrete arch ribs to each span, while the arch ring on the curved arch section is solid

reinforced concrete for the entire width of the bridge. This gives added strength and stability to the curved section.

The roadway on the bridge is 40 ft. wide, flanked on either side by a 6-ft. sidewalk. These, together with the railings will make the structure about 50 ft. wide. When completed, it is believed that this bridge will

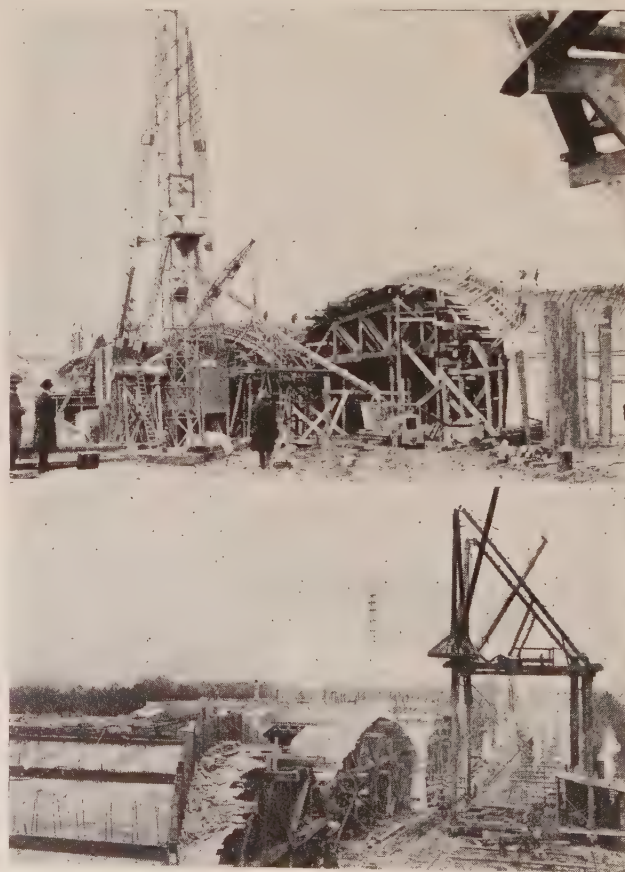


FIG. 1—MIXING PLANT MOUNTED ON SCOW, DISCHARGING CONCRETE INTO CAR

FIG. 2—DERRICK MOUNTED ON BROAD GAGE TRACK, PARALLEL TO TRACK FOR CONCRETE CARS. CONCRETE IS HOISTED BY THE DERRICK AND PLACED IN HOPPER PREPARED FOR IT ON TOP OF THE WORK

be the longest highway bridge in northern New York, being exceeded in length only by the 4 bridges in New York City.

Some of the interesting details are shown in the accompanying illustrations. In designing the curved arch, no analysis was made of the edges of the curve, but they were constructed with the purpose of low stress on the margins. Only 70% of the stress which

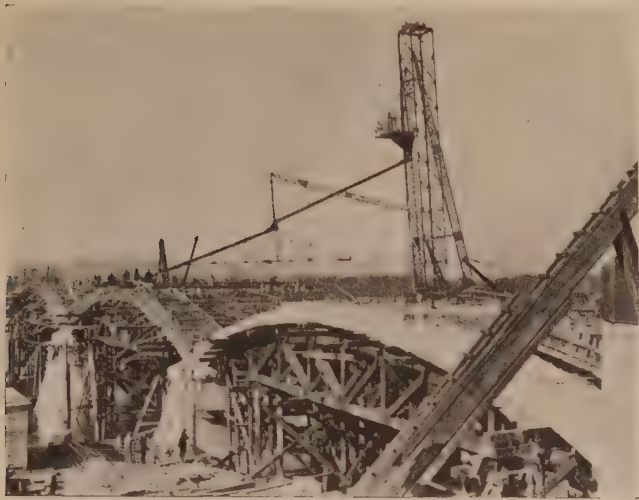


FIG. 3—DERRICK ON SCOW BEING USED IN CONNECTION WITH CHUTES FOR PLACING CONCRETE IN THE ARCH SECTIONS OVER THE WATER

would have been used had the arch been straight was allowed in designing the curved section.

Pier No. 4 is triangular in plan, two faces of the pier being arranged at such an angle as to make them parallel with the faces of the piers at the ends of adjoining spans. The triangular concrete cap, 6 ft. thick, rests upon wooden pilings, being left hollow in the center for earth fill. The piles are spaced 2 ft. 6 in. o. c. in both directions. In general, the piers were supported on 6-ft. reinforced concrete caps resting upon wooden piling about 25 ft. long. A triple lap wooden sheet piling considered to have a sustaining power equivalent to that of 1½ rows of round wooden piles was driven to the same depth as the round piles. Reinforcing bars have a lap of not less than 40 times their least diameter.



FIG. 4—GENERAL VIEW OF BRIDGE UNDER CONSTRUCTION SHOWING THE CURVED SECTIONS AT THE APPROACH TO VAN SLYKE ISLAND

FIG. 5—CLOSE UP VIEW SHOWING TRUSSES USED TO SUPPORT THE FORM WORK FOR THE ARCH RIBS

The aggregates used in the construction of the bridge consisted of sand and gravel obtained from the river bed a short distance away. These aggregates were sifted and graded for use and then transported to the bridge in special scows or boats constructed for the purpose. The proportions used were 1 cement, 2 sand and 4 stone aggregate.

At the bridge the contractors equipment consisted of a large mixing plant and derrick permanently mounted on a scow in the river. The materials were brought alongside this scow by the sand boat and transferred to the mixer bins by the derrick. After mixing, the concrete was dumped into a bucket, hoisted by the derrick and placed on a small car which ran along the

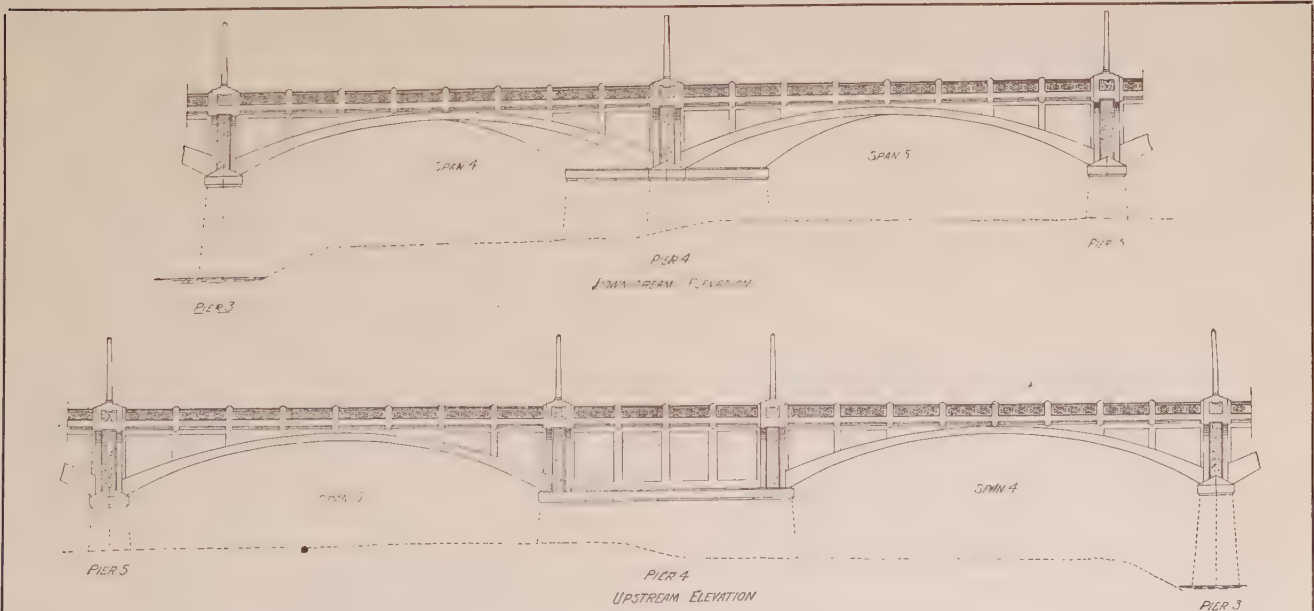


FIG. 6—ELEVATIONS AT TRIANGULAR PIER No. 4, SHOWING ALSO ADJOINING SPANS

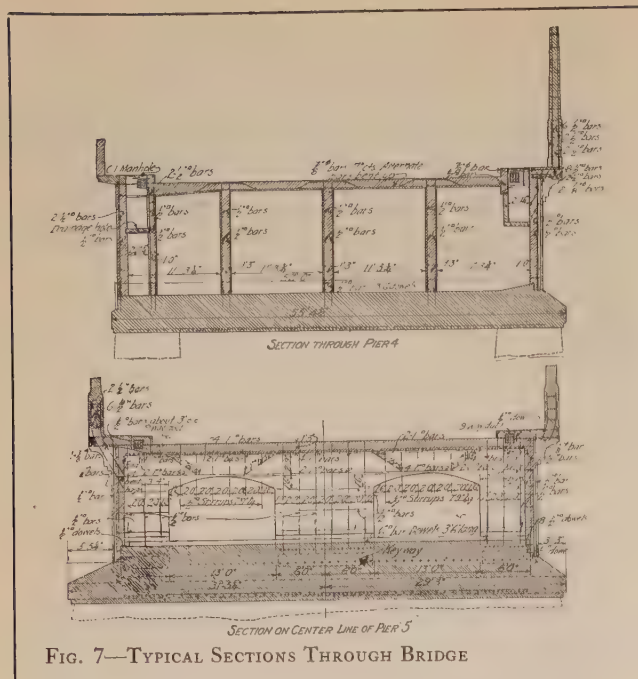


FIG. 7—TYPICAL SECTIONS THROUGH BRIDGE

track by the bridge to the point where it was desired to deposit the concrete. The scow was operated by electric power which was readily available at the site of the work.

A movable derrick was also provided which could be run along parallel lines with the car. The derrick was used to hoist all timbers to place for the construction of the forms and to lift the buckets and dump the concrete into the forms as the cars were brought with the concrete from the mixer. This method was used both on the island and the land approaches of the bridge.

Figs. 1 and 2 show the positions of the car and derrick and the track for their operation. Fig. 1 shows the mixing plant discharging concrete into the car to be hauled away to the forms. Fig. 2 shows the movable derrick mounted on wheels on the wide gage track parallel to the center line of the bridge.

In placing the concrete in the spans over the water, concrete was hoisted in the bucket directly from the mixer and dumped into the forms by the aid of the derrick on the scow. Figs. 3, and 4 show the methods employed in placing this concrete and in Fig. 3 the concrete is being chuted to a distant position with the aid of inclined chutes. Fig. 4 illustrates the curved section of the bridge looking across to Van Slyke Island.

The forms for the arches were constructed largely of wood, trusses supported on timber bents being used to support the forms as shown in Fig. 5. Structural steel supported by trusses was used to supplement the wooden structures in some particular cases.

New Billet vs. Rerolled Reinforcing Bars

Comparative Tests of New Billet Steel and Rerolled Steel Reinforcing Bars is the title of a new bulletin issued by the University of Wisconsin Engineering Experiment Station. The report is prepared by Jesse B. Kommers, associate professor of mechanics. The report fills 32, 6 x 9 pages. From the introduction we have the following as to inception and outline of tests:

In the autumn of 1921, Robert C. Johnson, Milwaukee representative of the Corrugated Bar Co., of Buffalo, N. Y., suggested these tests as a possible thesis to James W. Johnson, a senior in the civil engineering course at the University of Wisconsin. The Corrugated Bar Co. had made some tests during the summer of 1921, which showed that rerolled steel bars lost a considerable percentage of their strength in tension after being bent cold. It was suggested that a series of tests, similar to those of the Corrugated Bar Co., comparing the physical properties of new billet and rerolled reinforcing bars, would be of value to engineers and other users of reinforcing steel.

Such a series of tests was carried out during the school year 1921-22 by James W. Johnson, with the assistance of Leland L. Karas, a senior in the mechanical engineering course.

A second series of tests, amplifying the first, was carried out during the summer of 1922 by Honore C. Hubbard, a graduate of the chemical engineering course at the University of Wisconsin. The results of these two series of tests are described in this bulletin.

For the first series of tests, new billet steel of intermediate grade was obtained from one company, rerolled steel from a second company, and both types of steel from a third company. Two different sizes of bars were used for each type of steel. The tests made upon these steels were the commercial tension test, the cold bend test, and the tension test of the bar after it had been cold bent into a U shape and then placed in a template.

In the second series of tests, the material consisted of intermediate grade and hard grade new billet steel from one company, rerolled steel from a second company, and both grades of new billet steel and also rerolled steel from a third company. The tests carried out were the commercial tension test, the cold bend test, and the tension test of the bar after it had been bent cold into a V shape and then placed in a template. Some of the steel which remained from the first series of tests was tested at this time in the V bend tension test.

The tension test and the cold bend test were chosen for this investigation because they are the tests now specified in the Standard Specifications of the American Society for Testing Materials for new billet steel and rerolled steel reinforcing bars.

The U-bend test was chosen in order to determine whether either type of steel lost any percentage of its tensile strength after it had been bent cold. The V-bend test was chosen for the second series of tests because it was thought that the V-bend represented better than the U bend the actual bending to which reinforcing bars are subjected in practice.

The tests already mentioned were supplemented by some chemical analyses and metallographic examinations.

The report draws the following conclusions:

1. Deformed bars of new billet, intermediate grade steel showed satisfactory ductility. A large percentage of the bars fell below the strength requirements, especially for ultimate strength, 50% of the bars falling 11.4% below the ultimate strength requirement. This lack of strength seemed to be due to low carbon content.
2. Deformed bars of new billet, hard grade steel showed a small percentage which failed to meet the ductility requirements. A large percentage of the bars failed to meet the strength requirements, 65% of them falling 4.2% below the ultimate strength requirement. This lack of strength seemed to be due to low carbon content.
3. Deformed bars of rerolled steel all showed satisfactory strength. A large percentage of the bars, 42.5%, failed to meet the ductility requirements. However, the results for the bars from one company were considerably better than those from the other company.
4. Cold bending of new billet bars, both of intermediate grade and hard grade, did not decrease the tensile strength of these bars. None of these bars failed in bending to the U or V shape.
5. Cold bending of rerolled bars seriously decreased the tensile strength of these bars. Furthermore, 47% of these bars failed in bending to the U shape. However, the results for the bars from one company were very much better than those from the other company.
6. The standard cold bend test and also the U-bend and V-bend tests, showed that the rerolled bars were likely to be very unreliable in the matter of uniformity of material. The micrographs and the chemical analyses helped to explain this non-uniformity.
7. Projections on the rerolled bars made it more difficult for these bars to withstand cold bending, but when the bars had proper ductility, the presence of projections was of little importance.
8. The poor ductility of the rerolled bars seemed to be due either to a high carbon content, or a medium carbon content in combination with a high phosphorus content.
9. For the new billet bars, the results in the U-bend and the V-bend tests were practically the same. For the rerolled bars, on the other hand, the U-bend test was considerably more severe than the V-bend test.
10. In the opinion of the writer, the new billet bars, while not meeting rigidly all the ordinary requirements for such steel, yet may be considered as reasonably satisfactory. The rerolled bars, on the other hand, while of satisfactory strength, must be considered as very unreliable for work under conditions subjecting them to cold bending.

The Development of Cinder Concrete Building Units

(Continued from page 232)

matter with the fine particles to absorb the excess moisture of said fine particles, and combining the mixture with the binder to form a plastic body.

5. The process of making plastic bodies which consists in subjecting the coal ashes to a bath to substantially remove the coke by flotation, crushing the larger particles falling to the bottom of the bath, and combining such crushed larger particles with a binder.

6. The process of making plastic bodies which consists in reducing the water absorptive properties of coal ashes and substantially removing the coke both by a liquid bath, crushing the larger particles falling to the bottom of the bath, and combining such larger particles with a binder.

7. The process of making plastic bodies which consists in removing the coke from coal ashes by flotation in a bath, crushing the heavy matter falling to the bottom of the bath, while such matter is moist from the bath, at least partially drying the crushed matter, and combining with the binder.

8. The process of making plastic bodies which consists in subjecting coal ashes to a bath of a specific gravity greater than water to float the coke, removing the heavier matter from the bath, crushing the same and combining with a binder.

9. The process of making plastic bodies which consists in separating the fine particles from coal ashes, subjecting the residue to a bath of greater specific gravity than water to float the coke, removing the heavier matter, crushing the same, and combining it with a binder.

10. The process of making plastic bodies which consists in separating the fine particles from coal ashes, subjecting the residue to a bath of greater specific gravity than water to float the coke, removing the heavier matter, crushing the same, mixing the crushed matter with the fine particles, and combining it with a binder.

11. The process of making plastic bodies which consists in subjecting coal ashes to a bath containing lime and herring brine to float the coke, crushing the heavier matters and combining the crushed matter with a binder.

12. The process of making plastic bodies which consists in substantially removing the coke, crushing the large particles, subjecting the crushed matter to a bath which will form an insoluble coating on such crushed matter, and combining with a binder.

13. The process of making plastic bodies which consists in subjecting coal ashes to a chemical bath to remove the coke by flotation and to saturate the larger particles, crushing the larger particles, subjecting the crushed matter to a bath which will combine with the chemical of the first mentioned bath to form an insoluble coating on such crushed matter, and combining with a binder.

14. The process of making plastic bodies which consists in moistening coal ashes, subjecting the latter to a bath to separate the coke by flotation, crushing the heavier matter and mixing the latter with a binder.

15. The process of making plastic bodies which consists of subjecting coal ashes to a bath to separate the coke by flotation, agitating the bath by steam to assist flotation, crushing the heavier matter, and mixing with a binder.

16. The process of making plastic bodies which consists in separating coke from coal ashes, crushing the remainder and combining the crushed matter with a binder.

17. The process of making plastic bodies which consists in first separating the fine particles from coal ashes, thereafter separating the coke from the larger particles, crushing the remainder, and combining the crushed matter with the fine particles, and a binder.

The Bo Process has not attained the public notice that has been won for Straub blocks. A leaflet issued by the Cinder Products Corporation, (controlling Bo patents) 416 Union Trust building, Rochester, N. Y., reports tests as follows:

1. During the months of September and October 1923 a series of tests was conducted at Columbia University, New York, for the purpose of having the Bo brick approved for the use in the City of New York.

The brick were made at the plant of Burnett-Wilson-Pfohl, Inc. Buffalo, N. Y., where Bo brick have been successfully manufactured since 1922. The results of these tests were as follows:

A. COMPRESSION TEST

Highest Test: 5,225 lbs. per square inch.
Lowest Test: 4,665 lbs. per square inch.
Average of 5 brick: 4,920 lbs. per square inch.

B. TRANSVERSE BENDING TEST

Highest Test: 828 lbs. per square inch.
Lowest Test: 738 lbs. per square inch.
Average of 5 brick: 765 lbs. per square inch.

C. ABSORPTION TEST

The brick were dried to constant weight and then immersed in water for a period of 48 hours. Average of 5 brick: 6.3% absorption by weight.

D. COMPRESSION TEST AFTER 48 HOURS IMMERSION

The brick were tested while in the condition resulting from 48 hours immersion. Loss in strength based on air-dry compressive strength, 36.7%.

E. FIRE TEST

Two whole brick were placed in a gas furnace at room temperature and the furnace temperature was gradually raised to 1700° F. during a period of one hour. One brick was then plunged in cold water, the other cooled in air. Both brick were intact and the edges remained sharp.

F. FREEZING TEST

Five brick were submitted to twenty alternative freezings and thawings. The freezing temperature was below 15° F., the thawing temperature at least 150° F. Loss in weight, after twenty freezings: Average of five bricks, 1.9%.

G. COMPRESSION TEST AFTER TWENTY FREEZINGS

Average of 5 brick: 3,735 lbs. per square inch.
Loss, based on air-dry compressive strength: 24.1%.
All bricks were less than sixty days old at the completion of the test.

2. Bo Block tested at the Municipal Laboratory, Rochester, N. Y., October 28, 1923.

8x8x16 in. hollow block, 45% air space.
Compressive strength, 28 days old:

1,750 lbs. per square inch of net area.
967 lbs. per square inch of gross area.

This block was made at the plant of Raymond Wilson, Lockport, N. Y., where Bo block have been manufactured since 1921.

3. Bo tile tested at the Municipal Laboratory, Rochester, N. Y., January 31, 1924.

6x8x16 in. hollow tile, 50% air space.
Compressive strength, 28 days old:

1,592 lbs. per square inch of net area.
796 lbs. per square inch of gross area.

This tile was made by the Genesee Brick & Supply Corp., Rochester, N. Y., where Bo block, brick and tile have been manufactured since 1922.

4. Absorption. Tests made at Columbia University, New York, August 24, 1923.

Bo brick, 48 hours immersion:

Absorption by weight, 12.9%.
11.4%.

This test is typical of the numerous absorption tests made on Bo brick.

5. In the year of 1922 a series of tests including freezing and thawing tests was conducted at the Municipal Laboratory, Rochester, N. Y., on Bo brick as manufactured in Rochester, N. Y.

The tests were made in accordance with the American Society for Testing Materials' Standard Specifications for Building Brick. The freezing temperature was 15-20° F., the thawing temperature 60-70° F.

At the end of the freezing and thawing treatment the brick showed only superficial spalling on the edges submerged in water during the freezing.

The test was interrupted after forty-two (42) freezings.

Compressive strength, original brick:

One-half brick flat, average of five brick: 3,290 lbs. per square inch.
One-half brick on edge, average of five brick: 3,000 lbs. per square inch.
Compressive strength after forty-two freezings and thawings.
One-half brick flat, average of five brick: 3,364 lbs. per square inch.
One-half brick on edge, average of five brick: 3,426 lbs. per square inch.

It will be seen that these brick increased in strength by the freezing and thawing treatment, probably due to further hydration of the cement in the presence of the water during the tests.

Absorption of water by weight, 15.7%.
Average weight of brick material, 101 lbs. per cubic foot.

Einar Christensen, chemical engineer of the Cinder Products Corp., writes for CONCRETE an outline of Bo purposes and processes from which the following is quoted:

First of all, the aim of the Bo process is to procure a *clean and reliable* aggregate from cinders. Sand and gravel should never be used promiscuously in the making of concrete and the same is true of cinders to an even higher degree.

The Bo patent was issued August 28, 1923 as United States patent 1,466,083. The process, however, has been in successful operation since 1921. The plants in Lockport, erected in 1921, Rochester, N. Y. erected in 1922, Buffalo, N. Y. and Geneva, N. Y., all operate along the same lines in the purification of the cinders while they make different type units like brick, block and tile.

The characteristic part of the layout is the *purification plant* where the treatment of the cinders takes place. The raw cinders are obtained from a number of different sources like power plants, glass works, paper mills and other industrial plants. First the cinders pass over a magnetic separator where the free iron is isolated. We find that most cinders contain a large quantity of iron in the form of dust, nails, bolts, etc. which would endanger the crushers and cause defects in the finished products. They are then screened to isolate the dust and separate a certain quantity of the material finer than 1/4 in. This dust is not used in the plant. However, the Geneva plant is selling this waste product at 50c per cubic yard. A certain amount of the material finer than 1/4 in. is used without further treatment as part of the aggregate. The proportioning of these screenings depends upon the nature of the cinders.

The oversize material is discharged into the so-called purification tank where the coke is separated by flotation and the non-combustibles, called the clinkers, are washed before being carried to the crushing department. Our highest yield of coke has been 57% but the average yield at the various plants is about 15% to 20%.

The greatest care is taken in the crushing of the cinders in order to

obtain strength and density of the finished product without impairing the insulating properties of the material.

The manufacture of the finished products from this purified aggregate is similar to that of ordinary concrete products. Our Rochester plant, the Genesee Brick & Supply Co., produces 2,000 to 3,000 blocks per day. The Buffalo plant, Burnet-Wilson-Pfohl, Inc., has an output of 20,000 to 30,000 brick per day. The Geneva plant, the Geneva Brick Products Co., Inc., produces 800 blocks or 800 tile and 8000 brick per day.

In addition to the plants now in operation several plants are under construction and should be manufacturing Bo products this summer. I can mention that one of the largest plants in Pennsylvania that has been making cinder blocks of the old type, has taken out a license and is now installing our purification plant in order to make a better product. This plant has been using a select and rather expensive cinder but the Bo process will make it possible to use a cheap average cinder without impairing the quality of the product.

Mr. Christensen reports as to plant operations:

The following is taken from our records:

1. Plant in Lockport, N. Y. Owned by Raymond Wilson. Erected in 1920-1921 and used as experimental plant by the Cinder Products Corporation.

2. Plant in Rochester, N. Y. Genesee Brick & Supply Corp., Inc., 832 St. Paul St. Erected in 1921-1922 and first operated as the Bo-Cin-Pro Corp.

According to royalty statements the sales for 1923 amounted to 180,000—8x8x16 in. block; 65,000—brick.

This may not seem such a large output but the production that year was hampered by the extremely severe winter and the lack of yarding space that made it impossible to stock a reserve for Spring, when the demand took a sudden jump.

During the months of actual production the coke reclaimed was easily sufficient for heating the plant. Little of it was sold.

3. Plant in Buffalo, N. Y. Burnett-Wilson-Pfohl, Inc., foot of Ferry St., Erected in 1922.

According to royalty statements the sales for the year 1923 amounted to 2,057,000 brick.

Approximately 250,000 of these brick were used in the construction of the Teachout Lumber Co., where an interesting fire occurred. (Bo brick stood up well in comparison with clay brick and tile—Editor).

A large supply of coke is always on hand but I have no record of any sales. The plant uses cinders from several sources and finds the separation of the free iron to be essential. A visit to the plant will show the large quantities of dust and scrap iron isolated.

4. Plant in Geneva, N. Y. Geneva Brick Products Company, Inc. Erected in 1922. According to royalty statements the sales for the year 1923 amounted to 84,000—8x8x16 in. block; 60,000 brick.

This is a small plant in a small community. It is up-to-date and makes brick and block of unusually high quality. The manager informs me that this year's output is practically sold, owing to the erection of a college, schools and factory buildings in the vicinity.

The Geneva plant, as well as the Rochester plant, makes various sized blocks, 6x8x16 in., 8x8x16 in. and 8x12x16 in. In the above I have figured these equivalents in 8x8x16 in. blocks.

The amount of coke reclaimed in our different plants varies from day to day. I consider, however, the 15 to 20% mentioned in a previous letter, as a fair average. This by-product, of course, would only be of real importance in large plants. When I stated in my last letter that we reclaimed 57% of coke by volume from a typical New York cinder, I may add that this cinder was produced by one of the largest power plants with a sufficient output for several hundreds of thousands of brick per day. At that time I wrote the engineers asking if they knew about the coke content of their cinders, and they informed me that it was about 50% but they did not think it could be remedied without too much expense.

From C. E. Coughlin, of the Genesee Brick & Supply Corp., comes a letter in part as follows:

We are very glad to give you all the information regarding Bo process that has been the result of our experience thus far. This is our third year in the manufacture of Bo purified cinder products and our plant is now equipped to turn out from seven to ten thousand blocks per week, and also a small quantity of brick and other miscellaneous materials. Each year our production has been considerably increased but we have not as yet been able to anywhere near meet the demand.

Cinder building units have always been barred by the building code of Rochester. Before the authorities would allow Bo units to be used, they gave them the most exhaustive and severe tests imaginable. In fact, tests that no other products had ever been called upon to meet. Needless to say, they passed them in wonderful shape, the city officials being so well pleased that they immediately specified our products for all Rochester school buildings.

The recovery of coke is not the main fundamental of the Bo process. It is simply one of the results of the purification. The object of the purification is to eliminate all impurities, meaning not only coke but more especially the iron, acids and sulfur which are

the elements that have caused the prejudice against the use of cinder products.

The value of the coke as a commercial proposition depends entirely upon the size of the plant and also upon the source of cinders. We have one source of supply in which there is almost no coke and another one which will run an average of 40%. From our observations in different cinder plants, we would say that coke will easily average 25% in the general run of cinders. All of the coke which we recover is burned in our own boilers for steam curing, thereby greatly cutting the consumption of coal. The saving on this item will run from one hundred to two hundred dollars per month, which is more than enough to cover the cost of the purification.

The superiority of the Bo purified cinder blocks is very easily demonstrated by two simple tests—one a fire test, and the other a freezing and thawing. We have seen actual demonstrations of these two tests time and again and in every instance there has been no noticeable effect at all on the Bo units, while on the unpurified brick or block there has been a great deal of deterioration through the fusing of the sulfur and coke in the fire test, and through disintegration in the freezing and thawing test.

* * *

Present Quality—Future Maintenance of Standards

Of recent years we have learned enough about making good concrete in the manufacture of building units so that we may look confidently to a better maintenance of standards of quality. The fact that exact knowledge of good concrete mixtures shows big economies in production where a high degree of refinement in aggregate selection and mix proportions is applied will eventually apply the rule of the survival of the fittest to the concrete building unit producers. Those who do not apply scientific principles to concrete building unit manufacture will it seems likely be forced out of business by the better brains and resources (and consequent possibilities for more economical production) of those who do apply these principles.

In the face of all this it is hard to believe that equal care in the selection and combination of materials will not give desirable and more uniform results in the manufacture of building units from cement and cinders.

With the cinder sources so extremely various it is too much to believe that any and all supplies will give standard results when made up into brick or block.

When the Underwriters Laboratories made fire tests for Francis J. Straub about 700 blocks were shipped to Chicago from the Straub plant at York Pa.—the York Patented Building Block Co. From the official report of the Laboratories come the following:

Stood shipment with very slight breakage. Had a sulfur content of about 0.7% of the dry weight of the cinders and a coal and coke content of 18 to 19%.

DURABILITY

Blocks capable of withstanding long-continued exposure to weather conditions without material deviation. Specimen subjected to rather extensive series of tests involving saturation, freezing, thawing and drying suffered no visible deterioration. Compression tests made on blocks subjected five times to saturation, freezing and thawing, and then three times to saturation and drying, showed an average crushing strength of 750 lbs. per sq. in. and a minimum of 580 lbs. per sq. in. of the gross sectional area. These values may be compared with the average of 815 lbs. per sq. in. and the minimum of 650 lbs. per sq. in. the case of blocks that had not been saturated. It is believed that these differences are not significant in view of the characteristic variations in compressive strength commonly shown by tests of concrete products.

The strength of the blocks is sufficient to warrant their use in bearing or non-bearing walls, within the limitations commonly recognized as applying to materials of this character.

In general concrete blocks are considered suitable only for buildings of moderate height and with types of floor construction and of occupancy that will impose loads on the wall well within safe limits for Straub blocks.

It is believed that there is not thus far any generally accepted specification regarding the crushing strength of cinder concrete blocks. The building Code recommended by the National Board of Fire Underwriters states that "the average compressive strength for concrete blocks when tested with the cells vertical, shall be not less than 800 lbs. per sq. in." The blocks forming the subject of this report had an average crushing strength of 815 lbs. per sq. in.

The effects of the Impact Test were purely local.

*See CONCRETE, Feb. 1923, p. 78.

UNIFORMITY

The blocks can be produced commercially with the degree of uniformity sufficient for the purposes for which the material is intended. The dimensions of the blocks are determined by the dimensions of the forms in which they are cast. The density and the compressive strength are subjected to variation within rather wide limits. In the case of the blocks employed in the examinations and tests described in this report, all being the product of the same plant, examination of 12 blocks showed weights varying from 16 to 25 %. Compression tests showed ultimate crushing strength varying from 650 to 1140 lb. per sq. in. of gross sectional area. The cinders employed in the mixing of the concrete were of rather inferior grade with 18 to 19 % combustible material, the presence of unburned coal or coke being evident on visual examination. Approximately 40 % by weight of the cinders passed a 20-mesh sieve. The results of the tests made on blocks employing this inferior aggregate and a rather small proportion of cement, were so favorable, notwithstanding the variation in some important properties, as to justify the opinion that the variations noted are within permissible limits.

FIRE RETARDANT PROPERTIES

Straub cinder concrete blocks constructed of the materials and by the methods described in this report, can be employed for the construction of exterior or interior walls, bearing or non-bearing, which when exposed to fire on either side will prevent the passage of flame through the wall and function as a barrier to the spread of fire by heat conduction for at least 2½ hours. Application of a hose stream to either side of the wall during the first hour of fire exposure will not seriously impair its fire resistance.

No flame passage occurred during the fire endurance test and no through openings were found. The critical temperature of 300°F. was reached on the unexposed face at 2 hr. 58 min.

The strengths which it is sought to maintain in cinder concrete building units are in general lower than strengths commonly required in building units of gravel concrete. This leaves a narrower margin of safe variability. It is assumed that the blocks from York, Pa., were considered creditably representative or Straub would not have used them for the fire tests. The Underwriters' report shows 40% of strength variation in these.

While builders may safely forego some of the high strengths commonly expected of other concrete building units for the considerable array of compensating advantages, the word of caution to the cinder products people is important that so valuable a building unit may not come into disfavor through failure in quality.

One feature of great possible value in the cinder unit has been touched upon only—insulation. For years the magazine CONCRETE has consistently advised its readers to furr before plastering. Cinder block walls are being plastered direct with apparent satisfaction. It is understood that comprehensive tests will be undertaken to determine the comparative heat loss through cinder block walls plastered direct and other better known and longer used types of construction. If such tests bear out the confidence already felt in cinder units it will be another very important factor in their future use. So far their insulating value is assumed chiefly from casual inspection of dwelling house and other walls; from reports of fuel economy and from the results of the Underwriters Laboratories fire tests.

In Conclusion

In conclusion, certain elements of the cinder products situation stand out and should be given very serious thought.

The future of cinder concrete building units seems assured if reasonable intelligence is applied to the special problems of their manufacture and use and a greedy, get-rich-quick trait in human nature is made subservient to the dictates of sound business forethought. Without prejudice to patent interests it seems that quality may be kept within safe standard limits by either of two courses—the selection of good cinders or the purification of cinders of less desirable quality. This preliminary procedure must be followed

by proper crushing and grading, the use of sufficient cement and water, constant inspection of machine operations to insure thorough compacting (the lower corners sometimes give trouble) and a constant check-up by systematic tests.

Francis J. Straub began making cinder block in New Kensington, Pa., about 1913 or 1914; he applied for a patent in 1915 and got it in 1917. The development of his idea and the use of his patent have been continuous, attended by a good deal of commercial success.

The Straub patent is so far deemed fundamental in covering the use of cinders without admixtures or separation in making concrete building units and is sustained by the United States Circuit Court of Appeals. Anyone who takes advantage of the Straub idea and merely effects slight changes in aggregate with the obvious intent to evade the patent and without contributing a new or better idea, will do well to look up the decision in the suit of Straub vs. Campbell and Miller, from which quotations have been made. In this case a competitor was found infringing who sought to evade Straub's patent by the admixture of a small amount of sand. So far as we know at this time when there is an addition of a *large* amount of sand, in proportions which were common in cinder concrete construction long before the cinder block came into prominence, the character of the resulting concrete is entirely different from that which is obtained from cinders alone or with a slight admixture of sand, and the sand-cinder concrete lacks some of those characteristics which have made cinder concrete units valuable.

Available information seems to indicate that others used cinders to make concrete building units before Straub did. Did they use crushed whole cinders without separation? Did their work comprehend a complete process and a commercial success along the line of the Straub patent block?

Our information is not sufficiently complete to answer these questions, although they might have an important bearing on the whole matter.

The Detroit Straub plant in getting started and facing a big demand before all machinery was available, screened its cinders without crushing and had a good deal of difficulty in getting satisfactory results. The use of the complete Straub idea has given very much better results.

Straub has 50 odd plants in operation. Some are very successful; some mildly so; some are still small operators.

Sigurd Bo proposes the purification of cinders, removing part of the mass to recover the fuel and on the theory that a better product will result. He proposes to use only a *part* of the residue of the furnace grates. Bo statements of the operations of his plants have been included in this article.

A small operator who thinks he can haul aggregate from any cinder pile and make good building units on a commercial basis is probably doomed to failure from one of several causes—perhaps through patent infringement or failure to comprehend the scientific necessities of good concrete employing cinder aggregate.

The use of cinders involves serious problems, especially when used with little or no other aggregate. The industry as a whole would probably be best served by central control *provided that control is exercised even more firmly than heretofore and along the lines of more thorough standardization of quality*, with a view not merely to the exploitation of patent rights of whatever nature, but to get a just reward from serving the public with a valuable idea.

Public interest is all on the side of the man who can serve the public best at the least cost.



FIGS. 1-3—PLANT OF THE CALIFORNIA TYLITE CO., LOS ANGELES—FACTORY, YARD AND A TILE MACHINE

Light-Weight Tile in California

The California Tylite Co., a comparatively new \$100,000 corporation in Los Angeles, is making a light weight building tile on a McIntyre machine, with an output of 4500 5x8x12 units per day of nine hours.

The plant occupies about 2 acres of ground in a well-located part of the company's 9½ acres, and owns the siding put in by the Southern Pacific Railroad. While the acreage is legally in the City of Los Angeles on San Fernando Boulevard, locally it is referred to as being in "Glendale, Cal.," the city limits of the two municipalities being in the middle of the boulevard. Glendale is a progressive and rapid building city, and provides a good market for the product of the plant, as well as an ideal location for workmen and their families.

The manufacturing building consists of a part two-story reinforced concrete unit, 32 ft. x 72 ft., with a one-story addition for the "boiler" room. A later addition of tile was built onto the two-story section. The aggregate bins for the mixer are carried on the roof; mixers and cement storage are on the second floor, and tile machines on the ground floor. A belt conveyor carries the cement in sacks direct from cars to upper floor.

Aggregate is dumped from either bottom or side dump cars into the usual hopper, located under railroad track, and carried by sand elevator into the reinforced concrete storage bins—one for pea gravel, another for sand. A screw conveyor carries the aggregate along to the bucket elevator, which dumps into troughs running to bin on roof. From this latter point, the aggregate is carried through individual pipes for coarse and fine to the 4½-cu. ft. measuring box, and thence into the mixer. The mix, which varies with sieve analysis, is about 70% gravel and 30% sand—1 cement to 4½ combined aggregates.

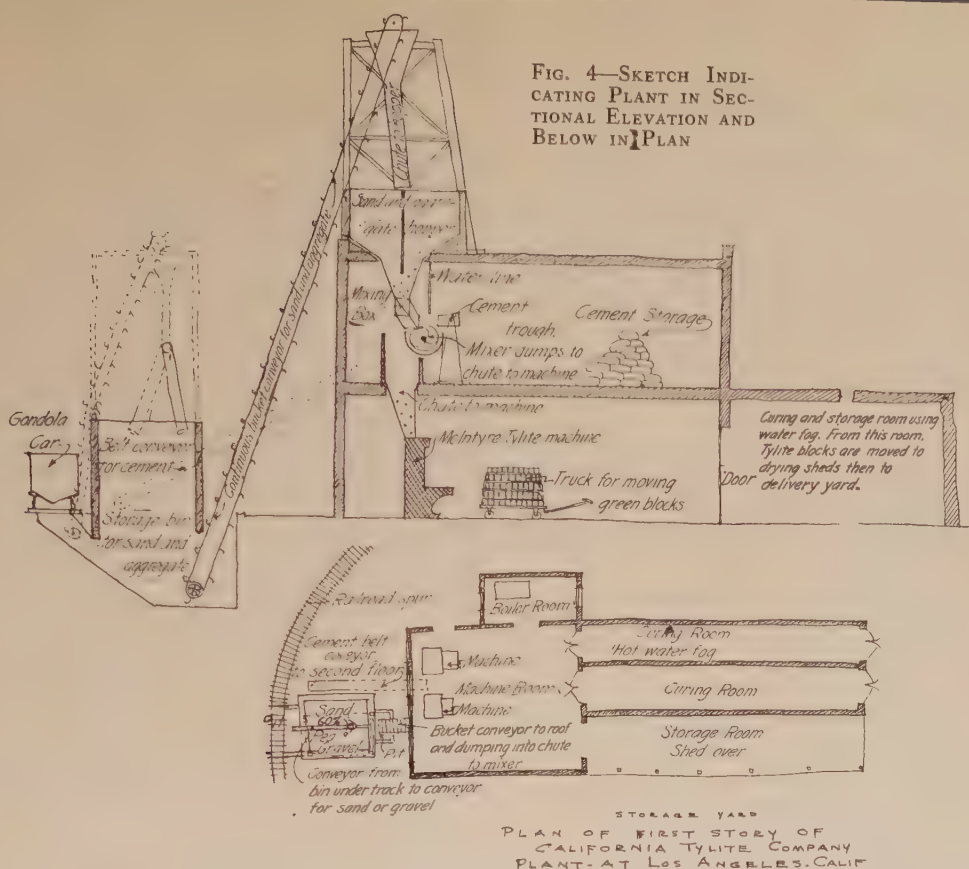
Blystone mixers are used, and, after the mix is ready for the machine, it is dropped down a chute to the lower floor to the tile machine. Tile are made in the usual way, stacked on racks, and taken into the tunnels with Barrett lift trucks.

There are at present two steam tunnels, each 105 ft. long x 11 ft. wide x 10 ft. high. They are divided into four compartments about equal in size. About two hours is required to fill each compartment with finished tile. As originally built, the tunnels had two steam lines, one on either side, with ½-in. down pipes into wells about 18 in. deep x 8 in. wide, spaced in pairs on 12-ft. centers. After considerable time was spent in tests, it was decided to install Skinner fog nozzles, inserted in ¾-in. pipe on 3-ft. centers, in each compartment, so arranged as to make each compartment independent. A Peerless water heater or boiler, fired with gas, is the unit for heating.

As now scheduled, the tile get a "hot water fog" about 3 hours after being made. Several applications are given the tile during the night by watchmen all on regular time-table method. Product can now be given moisture much sooner than was possible with the old steam system, when the tile stood from early morning until late in the afternoon before steam could be turned on. As soon as a compartment is ready for steam, it is applied—a wet steam bringing the temperature in the room for the first three hours up to about 100°. Then, in proper rotation, each compartment gets a hot water fog, which is some degrees cooler than the first application, but at no time is the temperature much above 100°. "The Skinner nozzles¹ are used for sprinkler systems for gardens, small farms, etc., and can be secured in several sizes," writes Mr. Hanley, manager of the plant. "The curing rooms have size No. 3; this gives a very satisfactory 'fog' or rain like spray. Unless a very large boiler were used to permit an extravagant use of steam and hot water, with its parallel expense of gas, this is the only thing we have found which could be operated economically, and at

¹Skinner Irrigation System at 4135 W. Pico Street, Los Angeles, Calif.

FIG. 4—SKETCH INDICATING PLANT IN SECTIONAL ELEVATION AND BELOW IN PLAN



the same time give water or moisture to the tile in an efficient way."

The tile are removed from tunnels in the morning following manufacture, and stacked in a shed, practically sun and wind proof, where they remain for 10 days, being sprinkled mechanically during this period. While this additional handling runs up the cost a trifle, it is deemed by the management to be good business.

A single shift consists of the following: one superintendent; two men on aggregate and mixer—one of these men looks after the elevating and unloading of material and helps the mixer man who is in charge of that portion of the plant; three men on machine—one placing pallets, two off-bearers, one man pulling tile to tunnel; two men drawing curing rooms and stacking outside curing shed; one night man, who continues the steam and hot water curing, cleans the machine, mixer, etc. Should an extra amount of aggregate or cement be received at one time, then extra help is picked up for the day.

The City of Los Angeles recently passed an ordinance governing the use of concrete block, tile, brick, etc. It is required of all products manufacturers that the name of maker, or his trade-mark, be imprinted on all units, together with date of manufacture. New pallets recently purchased carry "Tylite" on a lower web, and the date is stamped on tile after coming from the 10-day shed. Tiles are stacked in large storage yard in the usual way with indexes as to date made. No tile are permitted to move until fully 28 days old.

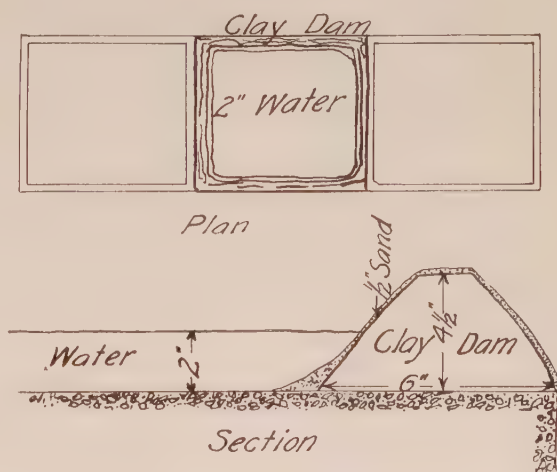
Present indications are for a healthy business; already considerable tile have been delivered to various jobs of business buildings, private dwellings, factories, etc.

F. H. Boettcher, is president of the company; C. H. Davies, vice president; G. C. Higbie, secretary; W. W. Charles, treasurer; L. A. Lewis, general counsel; J. C. Hanley, manager; F. M. Morrison, superintendent.

Clay Dam for Ponding

The accompanying illustration shows a kink, submitted by W. H. Waddell, chief concrete inspector, Dept. of Railroads and Canals, Welland Ship Canal Office, for ponding finished tops of concrete work by the clay dam method.

After the top of the concrete is finished and is hard enough, blue clay is worked up and a dam built, as



shown in the sketch, around the area that has been finished. Sand is then placed over the dam, $\frac{1}{2}$ in. or so thick, the sand extending well onto the finished surface, so that when the surface is flooded, the sand becomes moist over the dam, preventing it from cracking in the sun and letting the water out.

If the job is properly done in the first place, it requires no further attention, except addition of water from time to time for 10, 15, or more days, depending upon the condition.

Permeability Tests on Gravel and Stone Concrete

Tests made in 1914 and 1915 are just reported by the University of Wisconsin Engineering Experiment Station in a bulletin, *Permeability Tests on Broken Stone Concrete*, by Morton O. Withey, professor of mechanics, assisted by Christopher A. Wiepking, instructor in mechanics. From the introduction (the full report covers more than 50, 6 x 9 pages) we have the following:

In the years 1912 to 1914 a series of tests was made at the University of Wisconsin to determine the effect of various influences on the permeability of gravel concrete to water. A paper containing the results of these tests appeared in the *Journal of the Western Society of Engineers* in November, 1914. This bulletin is a report on a similar and subsequent series of tests on the permeability of broken stone concrete to water.

The specimens and tests described in this bulletin were made during the years 1914 and 1915. A total of sixty-one batches of machine-mixed concrete were prepared; each batch was cast into three or four permeability specimens and an equal number of compression cylinders.

More or less study was made of the influence of the following variables on the water-tightness of the concrete; the effect of age, thickness, richness of mix, grading of aggregate, time of mixing, consistency, curing treatment, and direction of flow.

Compression tests on 6 x 18-in. cylinders were also made to furnish data which would indicate whether or not water-tightness is related to the strength of the concrete.

The entire series of specimens is listed according to the batch numbers in Table 3. This table indicates the materials and proportions used, as well as the time of mixing and thickness of specimens. Tables 4 to 11 give further information regarding the differences in fabrication and treatment between some of the specimens.

Proportions of 1:1½:3 and 1:2:4 (by volume) and 1:9 (by weight) were selected for most of the mixes because such concretes are in the range of proportions which are used with similar materials in practice. Furthermore, it was found that the apparatus available for these tests would not detect leakage into concretes richer than 1:1½:3, and that mixes leaner than 1:9 were not dense enough to hold a pressure of 40 lb. per sq. in. in testing.

Acknowledgment is made to John Miller, former laboratory assistant, for careful work in preparing materials and making and testing specimens. F. D. Bickel, O. A. Bailey, Thomas Utegaard, and L. F. Nelson computed and tabulated the results of tests, and C. E. Ives drew and lettered most of the tables. Checking of the computations and the writing of this bulletin is largely the work of C. A. Wiepking.

The Universal Portland Cement Co. donated the cement used in the tests.

From the permeability tests on gravel and stone concretes which have been made at the University the authors of the bulletin draw the following conclusions:

1. None of the concretes tested were *absolutely* water-tight, if continuous flow *into* the specimen is considered proof of permeability. The specimens of rich mixes, when submitted to proper curing conditions, were so impervious that no leakage was apparent at the free surface. Such concretes can be considered water-tight for ordinary purposes.

2. The cement content of a given mix appears to be the most important factor in determining the degree of impermeability. Other factors remaining constant, the water-tightness of concrete made with well-graded aggregate increases with the proportion of cement in the mix. In the mixes tested, this increase in water-tightness was very marked as the cement content was raised, until the ratio of cement to aggregate, by weight, was 0.15. Further increase in cement content was attended by a relatively small increase in water-tightness. For the broken stone concretes of these tests, a ratio of cement to aggregate, by weight, of 0.17 or more gave a water-tight mix, whereas a cement-aggregate ratio of 0.14 was sufficient for the previously reported gravel concrete mixes. Mixes containing high proportions of cement were much less affected by variations in consistency, time of mixing, and grading of aggregate than lean mixes.

3. The ratio of the volume of cement to the volume of air plus water voids, or cement-voids ratio, is a valuable measure of both strength and water-tightness of concrete. The strength increases

nearly in direct proportion to the cement-voids ratio for the mixes tested. Water-tightness in the mixes of broken stone concrete was obtained when the cement-voids ratio was 0.55, or above. With the previously reported gravel-concrete mixes, a cement-voids ratio of 0.45 gave similar results.

4. The water-tightness of mixes containing less than 14% of cement to total dry materials, by weight, is much affected by variations in consistency, curing conditions, placement, and grading of the aggregate. It is also affected, but to lesser extent, by variations in the time of mixing, and by the moisture content of the fine aggregate. Lean concrete made of angular broken stone, are more sensitive to the effects of these variables than similar mixes containing round pebbles.

5. Maximum water-tightness obtains for a limited range of the water-cement ratio $\frac{w}{c}$. For the rich mixes, this range is much wider than for lean mixes.

6. A plastic consistency which gives a slump of 1 to 3 in. when tested in a 6 x 12-in. cylinder appears to be best suited to produce an impervious concrete with a minimum of cement. In order to secure maximum density, it is better to use somewhat more water than above indicated, rather than a lesser quantity; but the use of excessive amounts of water, which is usually accompanied by segregation of the aggregate, greatly increases the permeability of lean mixes.

7. When conditions of placement require the use of a more fluid mix than recommended above, increased fluidity may be obtained, without sacrifice of imperviousness, by raising both the cement and water contents in the same proportion.

8. To secure a high degree of imperviousness, concrete should be cured in a moist atmosphere or under water. At temperatures of 60° to 75° F., the moist-curing period should be maintained for two weeks to a month after molding. Lean mixes or thin sections require longer wet-curing periods than rich mixes or thick sections. When it is impracticable to keep the work moist after removal of the molds, and the humidity is low, provision should be made to keep the molds in place in order to avoid evaporation. The effect of dry curing appears to be much more detrimental to water-tightness than to compressive strength.

9. Thorough mixing is of great importance in securing the homogeneity necessary in water-tight concrete. Considering only the consistencies more commonly used, slumps 1 to 10 in., it appears that lean mixes made with damp sand require a somewhat longer mixing period than when made with dry sand. With a mixer of the type used, a mixing period of 1½ to 2 minutes after all materials have been placed in the machine is required to secure thorough mixing of lean concretes. Materials for such concrete should be mixed dry from 15 to 30 seconds before water is added.

10. With lean mixes, very much greater care must be exercised during placement to secure sufficient homogeneity so that they will be impervious when the direction of flow is parallel to the bed. The rich mixes of 1:1½:3 proportions exhibited practically the same degree of water-tightness for flow normal to or parallel to the bed.

11. The results show that lean mixes in which the materials have been proportioned in accordance with Fuller's mechanical analysis curve can be made very impervious provided it is possible to use a plastic consistency and to secure proper methods of placement and curing. Therefore, when a construction involving a large yardage of concrete is being planned, the properties and the costs of lean mixes made of specially graded aggregates should receive due consideration.

12. For making water-tight concrete, well graded gravel of good quality is superior to broken stone of like quality and grading.

13. For properly placed and cured broken-stone or gravel concrete, the permeability decreased as the compressive strength increased, until the latter reached 2500 lb. per sq. in. Concretes of this strength were water-tight.

14. For the concretes tested, increasing the thickness above 6 in. did not materially affect the leakage at pressures of 40 lb. per sq. in. With the more variable conditions of mixing, placing, and curing encountered in the field, sections thicker than 6 in. would undoubtedly be required for water-tightness.

15. The permeability of rich concrete cured in moist air for one month and subsequently protected from the weather, decreases with age, but the decrease is negligible after the concrete becomes one month old.

16. When concrete is subjected to freezing, its permeability appears to be increased slightly. Weathering agencies, such as combined freezing and thawing, wetting and drying, and variations in temperature seem to produce a marked increase in permeability. The effect of these agencies must be more thoroughly investigated, however, before their magnitude can be stated.

Index, Vol. 24, CONCRETE, January to June, 1924, will be ready July 1st.

Graded Aggregate

Nation's Rents Continue to Rise

Despite decreases in the costs of many factors entering into the budget of the average American family, the nation's rents bill continues to rise, according to the latest country-wide survey of the housing situation by the National Industrial Conference Board of 10 East Thirty-ninth Street, the results of which were summarized in an announcement recently made public. Taking the United States as a whole, the increase amounts to an average of 85% in the last ten years. In four months ending March 15, it was 3%, and in the last twelve months it was 9%.

The conference board, which is the research organization for the leading industrial associations of the country, finds that in the rent advance the East and Middle West lead.

* * *

Good Workmanship Essential to Good Stucco

The selection of a stucco contractor who knows his business and can show that he has done good work is the most important factor in securing good stucco construction says a bulletin of the Bureau of Standards. At least, in the present state of the art, more depends upon capable workmanship than upon many of the details of the specifications. The successful stucco specialist may be expected to know the requirements of the specifications, and will also have acquired a knowledge of the application of the material which can be learned only by experience. The plasterer trained for interior work does not have this necessary knowledge and experience, the Bureau believes, and the saving in cost by hiring an inexperienced man will be made at the expense of appearance and durability of the job.

Tests on stucco construction have been in progress at the Bureau since 1911. Panels of stucco made in accordance with different specifications have been constructed and exposed to the weather for a number of years. Some of these panels were of back plastered construction; some were made with wooden sheathing. Paper backed construction plaster board, and other types were also tested. Still others were applied to walls of masonry.

Measurements of the shrinkage of stuccos were also made by means of a special comparator. It was shown that this shrinkage may be controlled to a large extent by regulation of the amount of water used. The general rule is that the material should stiffen from removal of water before chemical set occurs, and the ability to recognize this condition is considered a necessary part of the plasterer's practical knowledge of his craft.

Masonry walls were found to make the best bases for stucco, and on them the finest stucco textures can safely be used. Fine textures are not recommended for use on frame construction, as they show cracks which are not visible in coarser textures. Where stucco is used on wooden frame, the frame should be well braced, and the use of metal or wire fabric or metal lath for reinforcement is recommended. The tests showed that better results were obtained by omitting the sheathing, using special insulation and bracing where required. If sheathing is used, it is thought horizontal sheathing would be preferable to the dia-

gonal sheathing which was used in most of the sheathed test panels.

Special attention, the Bureau says, should be given to the tying or lacing of the fabric or lath, so that the joints do not constitute a line of weakness in the reinforcement.

Lean mixtures were found to give the best results. A mixture of one part cement, one-fifth part of hydrated lime, and three parts building sand is the richest recommended. Good design is considered essential, and involves adequate flashing and overhead protection, and the restriction of stucco construction to vertical surfaces or to those which will drain quickly.

* * *

Concrete Masonry House Gets More Advertising

The Chicago Daily News is building three homes, one on the north, one on the west, and one on the south side of Chicago, to educate prospective home builders in how to go about building. The house on the north side is being constructed of concrete block with portland cement stucco. The Greater Chicago Concrete Products Association is responsible for having the concrete masonry house included in the list, and is expending \$2000 advertising concrete masonry houses. *The Daily News* circulates all over the State of Illinois, and will help concrete products men throughout the state.

* * *

Corrosion of Metals

The work which the Bureau of Standards is carrying on in cooperation with the A. S. T. M. on the corrosion of metals is beginning to yield some interesting data. There is, however, the difficulty of interpreting the information obtained correctly, and until this can be done with greater certainty, it is not wise to draw definite conclusions. One surprising feature of the work is that at least in the case of some alloys, the alternative immersion test, in which the specimen is first suspended in air and then in the corrosive medium is not as severe as the simple immersion test. A great deal of work has been done in the comparison of methods of suspending the specimen in the corrosive medium, and tentative conclusions have been drawn as to the most suitable method for specimens of several shapes. A paper describing the apparatus developed is being prepared for presentation at a forthcoming meeting of the A. S. T. M.

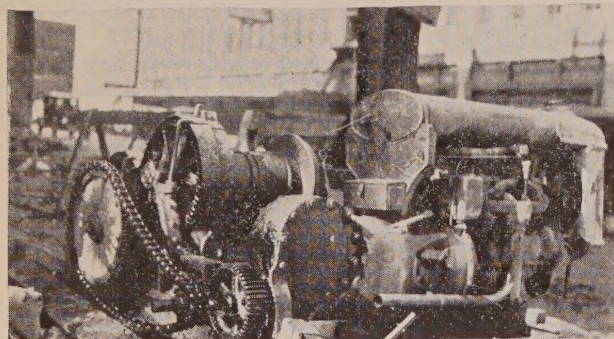
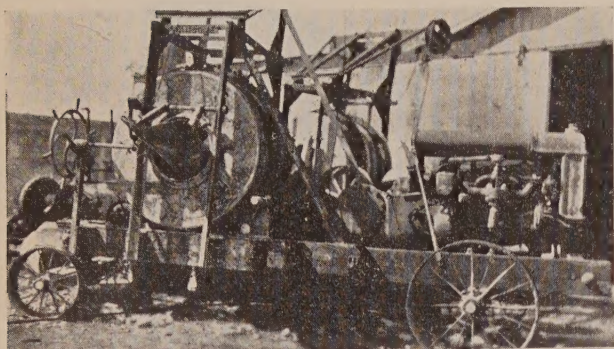
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Macon Roller Patent Matter Settled

The Associated General Contractors of America announce from Washington that the construction industry has been freed from prospects of prolonged litigation as a result of an agreement reached here in the situation involving alleged infringements of patents covering use of the Macon Concrete Roller. The agreement, drafted by representatives of the manufacturers of the device and officers of the Associated General Contractors takes the entire affair out of the courts and places it on a cooperative basis. Under the terms of this agreement, all suits pending for past royalties against the A. G. C. members will be called off, and no further suits will be undertaken. The agreement provides that in the future contractors may either purchase rollers from the Macon Concrete Roller Co., Macon, Ga., or make their own rollers, the charge to be made for each roller, including the price of the roller, will be \$50 per annum for the first year and \$30 per annum thereafter. If the contractors

Adapting the Fordson to Concrete Work

By GRADY TRIPLETT



For both mixing and hoisting concrete, J. B. Townsend, contractor of Houston, Texas, has adopted the Fordson engine. He has seven of these tractor engines in his equipment, accumulating them over a two-year period. They are cheaper on the first cost and cheaper under operation than steam power.

The engines have been rigged up by H. A. Showalter, construction superintendent of the contractor. He has assembled the units by use of new equipment, combined in many instances with some old equipment.

Hoisting machines have been somewhat standardized, after experiments with various methods of getting the power of the engine to the drums. As now used, the drums and frame of a discarded steam hoisting outfit are taken. The drums, of course, must be in such condition that they can be made serviceable by repairs and replacements. After the steam engine and boiler are removed, the Fordson engine is attached to the frame.

A sprocket is attached to the Fordson tail shaft, and the drums driven by a chain. Chains put out by the White Co. have been adopted. With this arrangement, the Fordson motor is left running continuously, and the drums are controlled by the friction clutch and brakes, as when driven by steam.

One man can operate a unit of this type. The fuel for an eight-hour run is around 15 gallons, kerosene being used. Fuel and oil for a day cost around \$2.

No one method has been adopted for driving concrete mixers with the Fordson. One outfit, using bevel gears from the tail shaft direct to the mixer, has given satisfaction. The gears run in oil. This mixer was used in the construction of a seven-story building in Houston. It furnished the mix, while another Fordson lifted 190 yd. of concrete for the

sixth floor over an eight-hour period.

It is in the smaller portable outfits that the Fordson has given great satisfaction to the Houston contractor. He has one such outfit, in which the Fordson is mounted on the frame of the portable mixer and the rear end of a truck used for taking the power from the tail shaft to the mixer. A special housing has been made to protect this truck differential.

Perhaps the most economical use of the Fordson in concrete construction is the double duty outfit, constructed to mix and lift concrete simultaneously. This is accomplished by using a belt from a pulley for the mixer and the sprocket arrangement for the hoist. The pulley was attached as provided on the shaft of the Fordson tractor. Then a belt was used to drive the mixer. The drums were rigged as all others are.

While one batch was in the mixer, another was being lifted to the top of the forms. This outfit was used on a two-story building, and is considered best for buildings of this class, as the Fordson will not give sufficient power for running a mixer and driving the drums of a hoist for higher lifts.

Mr. Showalter has a plan for rigging two Fordsons to one set of drums for high lifts, in constructing big buildings. So far, he has not had to use this. But his plan is to remove both engine and boiler from the frame of a steam power hoist. This will leave room for two Fordson motors. Both will be attached to the drums by sprocket chain drives. Then a governor will be installed to equalize the power and speed of the two. This arrangement, he believes, will give sufficient speed and power for hoisting in constructing buildings higher than 10 stories.

Fordson power was used exclusively in the concrete work on the Long Reach plant of the Houston Compress Co. This plant, the largest cotton compress in the world, required 180,000 yds. of concrete. Two Fordson driven mixers turned out the material, while other Fordsons raised it to the forms.

Only new engines are bought. The efforts made to adapt used motors did not prove successful. But hoisting drums from steam outfits have served to good purpose. Most of those in the Townsend warehouse have come from discarded steam outfits. By using old drums with a new motor, the Houston man has set up his complete units at less than \$1000 each. Then their operation is much lower than when using other power.

CONSTRUCTION COST ACCOUNTING, by Weston J. Hibbs; size, 5 $\frac{3}{4}$ in. x 8 $\frac{3}{4}$ in.; 60 pp; paper covers; price, 75¢ per copy. National Association of Cost Accountants, 130 West 42nd St., New York City.

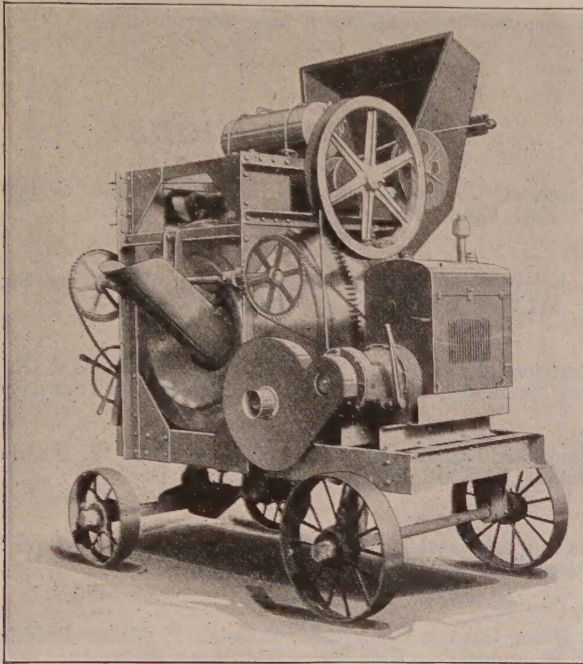
This publication which is Vol. V, No. 15 issued under date of April 15, 1924, is written from both the view point of the contractor and the customer, and outlines first the results that should be obtained from a construction cost system and the fundamental principles.

Among the points covered are the estimate sheet, memorandum sheet, monthly bills, general expenses, reserve accounts, insurance and monthly summary of costs. The three forms shown and marked exhibits A, B, and C are the estimate sheets, final bills and summary of costs divided into accounts of work ordered. This book commends itself to anyone concerned with cost accounting, particularly with construction cost accounting with due consideration for the needs of both the contractor and the customer.

New Smith Non-Tilting Mixer

A new development of the Smith 14-S Non-Tilting Mixer is shown in the accompanying illustration. Greater compactness of construction permits mounting on shorter trucks, thereby making the entire machine lighter, and greatly increasing its portability.

The picture shows the Smith 14-S equipped with power loader, water tank, and 15 h. p. 4-cylinder



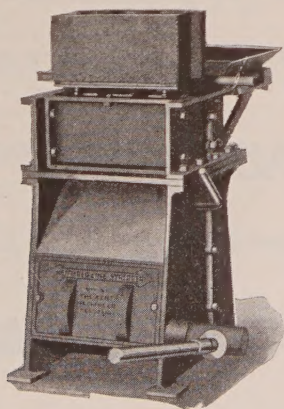
NEW SMITH 14-S TWO-BAG MIXER

Le Roi power unit. Strongly built gear guards protect the workmen and at the same time prevent falling aggregate from dirtying and injuring the gears.

This is claimed to be an ideal mixer for any construction job, whether large or small—having a two-bag capacity and giving a daily production of more than 150 cu. yd.

New Kent Stripper Block Machine

The Kent Machine Co., Kent, Ohio, has brought out a stripper block machine as an addition to its Red Line products. It is built to withstand hard usage. The main frame of the machine is cast in one heavy piece. The weight is figured to absorb the shock of the tamper



which may be placed over the machine, thereby throwing the pressure back into the block where it belongs, and at the same time extending the life of the machine.

The cores for this stripper are made of any shape or size to fit any pallet, to give either a 33%, 40%, or an

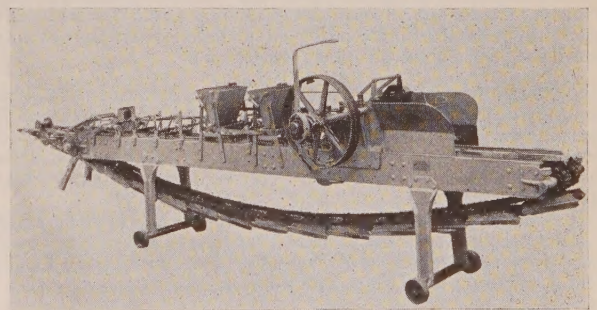
intermediate or larger air space if desired. These cores are held securely so they cannot work out of place and get under the tamper foot. The machine is built low so it will not have to be set into the floor to give a satisfactory working level.

The stripper cross head is actuated by a new cam and crank mechanism, which does not require any foot treadle to start the block out of the mold box, but which strips it very easily. The cam action starts the block out of the mold box very slowly, and with an extremely small amount of power on the part of the operator. The speed with which the block is stripped is gradually accelerated until the maximum speed is obtained, when the block is about two-thirds of the way out. The speed is then again retarded to a very slow speed, when the block stops at the top of the stroke. When the block is in its highest position, the lifting cross head is automatically locked, and stays there until it is unlocked by tripping a small handle at the right of the machine, which allows the stripping lever again to swing into its high position. The machine is provided with a hopper and strike-off arrangement of simple design.

The Kent company has purchased the right, title, and interest in all patents, patterns, machinery, tools and equipment of the Hayden Automatic Block Machine Co., Columbus, Ohio, and is now prepared to furnish the machines formerly manufactured by the Hayden people to the products trade. These include the Hayden stripper block machine, in all sizes from 8x8x16 to 8x12x24, and the Hayden down-face machine in all sizes, either with square or oval cores.

Schwarz Automatic Roof Tile Machine

A new automatic roof tile machine put on the market by Schwarz Bros., 69 Cherry St., Bridgeport, Conn., is described by the manufacturers as follows:



The machine is a complete unit, with a continuous chain to carry the pallets. It measures 20 ft. long over all, and requires two men for its operation; one to feed in the mortar and pallets and the other one to carry off the tile. There are no adjustments to be made or watched, save one—a thumb-screw controlling the amount of color. This is set when work is started, but can be adjusted easily while the machine is running. The color is applied in powder form, prepared the same way as for hand outfits. The mortar is of about the same consistency as that used on hand machines. So far, we have built machines to take Walter Concretile pallets, but can build them to take any other forms. Of course, only one kind of pallets can be used on any machine.

The capacity of our machine is 7 tile per minute. This is perhaps not the maximum the machine can produce, but it is pretty near the maximum the men serving the machine can handle.

Our experimental machine was sold to the D. & P. Tile Co., which makes only about 1300 tile per day at present, running the machine but a few hours, as that is the limit of their shop equipment racks, pallets, etc. This experimental machine, not built for hard continuous use, will be replaced soon by the perfected outfit.

Our machine embodies many features which we believe have never been tried before. It was considered difficult to trowel mechanically a tile with the color sifted on in dry form and to form the interlocking bead. We found simple and reliable ways to overcome these troubles. The picture is of our first machine. The machines we are building are identical in principle, but differ considerably in design, being more substantial.

Trade Publications

Style in Roofs is a 24-page book in colors, 8 in. x 10 $\frac{3}{4}$ in., designed to help the home owner and the home builder select the right roofing unit as to form, texture, and color for his particular house, as influenced by the design, material, and color scheme of the house itself and its surroundings. The book is issued by the Beaver Products Co., Inc., Buffalo, N. Y., and has numerous illustrations in color and in black and white, showing many types of house architecture and giving roof suggestions for each one.

Ideal Concrete Machinery, the Ideal Concrete Machinery Co.'s catalog No. 35, has 80 pages 8 $\frac{1}{2}$ x 11 in. and a price list in addition, put out in loose leaf style in an attractive cover. It is a new catalog of Ideal equipment for making standard and ornamental units, and has numerous illustrations of the uses of the products. This publication is, in a sense, a celebration of the company's recent move into a new and larger factory, 5000 Spring Grove Ave., Cincinnati, Ohio.

The Book of Elastite Expansion Joints, by the Philip Carey Co., Cincinnati, Ohio, contains 72 pages and cover, 8 $\frac{1}{2}$ x 11 in., profusely illustrated, showing uses of Carey Elastite expansion joints in the many types of structures, including roads, streets, driveways, sidewalks and other paved areas of concrete, brick, granite, or wood block, in bridges, retaining walls, dams, reservoirs, swimming pools, stadiums, roofs, floors, and other structures.

The Bullis Form Clamp is the title of a folder issued by the Washington Steel Form Co., Washington, D. C., cataloging the Bullis form clamp, which is described as a simple device, efficient and indestructible.

The catalog is illustrated, and contains directions for applying the clamp. Prices are also listed.

"What Would Your Answer Be?" is the title of Bulletin 32, issued by the Pittsburgh Testing Laboratory, Pittsburgh, Pa., giving typical questions and answers taken from a case in court, resulting from the collapse of a concrete structure. The Pittsburgh Testing Laboratory has cement laboratories, located in important centers, which are used exclusively for testing cement prior to shipment from the mills.

Health Bulletin on Sewage Disposal is the title of an educational pamphlet being distributed by the United Cement Products Co., Indianapolis, Ind. It is issued by the research department, and contains authentic facts on sanitary sewage disposal, and describes the Perfection septic tank, a system of sewage disposal without sewers, manufactured by the United Cement Products Co.

The pamphlet describes and illustrates the Perfection septic tank, layout for disposal of effluent from septic tanks, and typical installation. Considerable information is included regarding essential features of efficient septic tank construction.

For the purpose of giving the warehouse trade information, which has been collected during a year of investigation, concerning the maintenance and profitable operation of motor equipment, the General Motors Truck Co., Pontiac, Mich., has prepared a new booklet, *Warehouse Transportation*, for free distribution to warehousemen.

The booklet contains data on the tractor-truck and trailer system of transportation, selection of bodies, capacity weight tables, operating costs, a base rate table for local and long-distance hauling, federal and state legislation, and truck specifications.

Waterproofing With Cal is the title of a 4-page, 8 $\frac{1}{2}$ x 11-in. folder published by the Security Cement & Lime Co., Hagerstown, Md., manufacturers of Cal. Information is contained in the folder as to what Cal is and for what purposes it is used. Specifications for waterproofing with Cal and current price lists are included.

The George Haiss Manufacturing Co., Inc., New York City, has issued Bulletin No. 424, *Haiss Model FC Path Digging Truck Loaders*. The Haiss model FC loader relieves the burden of hand-shoveling costs and makes for greater profits, it is claimed. It has a Fordson power plant and creeper tread mounting, is self-feeding, self-crowding, and self-propelling. It is recommended as especially suited for road builders. This equipment is a powerful and heavily constructed machine which will dig and load any loose material which does not weigh more than 125 lb. per cu. ft., is not stickily adhesive, and is in lumps not larger than will pass through a 3-in. ring. The more common applications are loading: crushed stone, sand, gravel, coal, coke, ashes, soil, and other loose materials.

A new catalog has been announced by the Detroit Steel Products Co., Detroit, Mich., containing illustrations and descriptive matter on a new line of domestic casement windows to be sold under the trade name Fenestra.

These new casements are available in numerous types and sizes, and are recommended particularly for homes and apartment buildings. Copies of the above catalog may be had by architects, contractors, investment builders, etc., upon application to the manufacturers.

Matthews Mechanical Painting Equipment. Bulletins 101, 103, 110, and 120 of the W. N. Matthews Corp., St. Louis, illustrating and describing mechanical painting equipment for the paint contractor; similar equipment especially adapted to the use of railroads and industrial use, and for maintenance work in industrial plants. The equipment for the painting contractor is mounted on a special Ford chassis with a special body fitted with cabinets, ladders, racks, tackle hangers, curtains, etc., and with a Matthews special compressor and engine; three Matthews material guns or nozzles, hose, and miscellaneous equipment. A feature of the Matthews equipment is the "gun," planned to be particularly efficient in applying paint, atomized, without spray. Such equipment is being used successfully by many contractors at a very large reduction in labor cost on jobs of many different kinds.]

Organizations

American Concrete Institute; Harvey Whipple, Secretary
1807 East Grand Boulevard, Detroit.

American Concrete Pipe Association; M. W. Loving, Secretary, 111 West Washington St., Chicago.

American Engineering Standards Commission; Dr. P. G. Agnew, Secretary, 29 W. Thirty-ninth Street, New York City.

Associated General Contractors of America; G. W. Buchholz, Secretary, 1038 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 W. Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference; Rudolph P. Miller, President, Fred W. Lumis, City Hall, Springfield, Mass., Secretary.

Iowa Cement Stave Silo Association; H. E. Kilmer, Secretary, Oskaloosa, Ia.

Iowa Concrete Products Association; Ross Dowell, Secretary, 405 Hubbell Bldg., Des Moines.

Mid-West Concrete Products Association; D. R. Donlen, Secretary-Treasurer, 4340 Marcy St., Omaha, Neb.

National Association of Manufacturers; John E. Edgerton, President; Henry Abbott, Treasurer; George S. Boudinot, Secretary, 50 Church St., New York City.

The National Concrete Stave Silo Association; W. G. Kaiser, Secretary, 111 West Washington St., Chicago.

National Crushed Stone Association; A. P. Sandles, Secretary, 405 Hartman Bldg., Columbus, Ohio.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East 22nd St., N. Y. C.

The National Lime Association; Mather Bldg., Washington, D. C.

National Sand and Gravel Producers' Association; T. R. Borrows, Acting Secretary, 903 Munsey Bldg., Washington, D. C.

Portland Cement Association; William M. Kinney, General Manager, 111 West Washington Street, Chicago.

Wisconsin Concrete Products Association; D. R. Collins, Secretary-Treasurer, Milwaukee.